LECTURES

ON

COMPARATIVE ANATOMY;

IN WHICH ARE EXPLAINED

THE PREPARATIONS

IN

THE HUNTERIAN COLLECTION.

ILLUSTRATED BY ENGRAVINGS.

TO WHICH IS SUBJOINED,

SYNOPSIS SYSTEMATIS REGNI ANIMALIS,

NUNC PRIMUM EX OVI MODIFICATIONIBUS PROPOSITI.

By SIR EVERARD HOME, Bart.

V.P.R.S F.S.A. F.L.S.

SERJEANT SURGEON TO THE KING; SURGEON TO THE ROYAL HOSPITAL, CHELSEA; SENIOR SURGEON TO ST GEORGE'S HOSPITAL, HONORARY PROFESSOR TO THE ROYAL COLLEGE OF SURGEONS, TRUSTEE TO THE HUNTERIAN COLLECTION; PROPRIETOR OF THE ROYAL INSTITUTION, CORRESPONDING MEMBER OF THE ROYAL INSTITUTION OF FRANCE; MEMBER OF THE ROYAL SOCIETY IN GOTTINGEN, MEMBER OF THE PHYSICO-MEDICAL SOCIETY OF ERLANG, HONORARY MEMBER OF THE MEDICAL SOCIETY, PHILADELPHIA, HONORARY MEMBER OF THE ROYAL MEDICAL SOCIETY OF EDINBURGH, CORRESPONDING MEMBER OF THE MEDICAL SOCIETY, DUBLIN

TO

HIS MOST EXCELLENT MAJESTY

KING GEORGE THE FOURTH.

SIRE,

I HAD the honour, eight years ago, of laying at YOUR MAJESTY's feet two volumes of LECTURES on COMPARATIVE ANATOMY, read before the Royal College of Surgeons in the years 1810 and 1813.

YOUR MAJESTY had not then ascended the throne of Your Royal ancestors; but, as PRINCE REGENT

of these Realms, had begun a career of glory, which, under an all-wise Providence, continues to surpass the brightest æra recorded in history.

If at that time, Sire, my heart was penetrated with the deepest sense of gratitude and duty towards YOUR MAJESTY, who, not only in compliance with the declared intentions of YOUR ROYAL FATHER, previous to HIS MAJESTY'S decease, created me a Baronet, for my professional assistance to the Duke of Cumberland, when severely wounded by an assassin, but most graciously gave me, under YOUR MAJESTY'S sign manual, an augmentation to my arms of the label of the King's fifth son, denoting the transaction for which I had obtained these honours;

I was not then, Sire, more sensibly alive to the honours conferred upon myself, than to those bestowed upon my profession, by YOUR MAJESTY'S Royal visit to the College, and the praise bestowed upon our laudable and humane pursuits.

If my feelings towards YOUR MAJESTY at that time were such, how shall I express what they are now, both as a dutiful subject and devoted servant, for the benefit YOUR MAJESTY has bestowed upon the Country, the College of Surgeons, and myself.

YOUR MAJESTY has given Peace to Europe by the most splendid Victory that ever was obtained.

YOUR MAJESTY has condescended to patronise Surgical Science, by raising the College of Surgeons to the highest honours a college can enjoy, and bestowed upon it the emblem of magisterial authority which can only emanate from the Crown.

YOUR MAJESTY'S Royal favour has raised so humble an individual as myself to be the first President of that College, the record of which is perpetuated in the inscription on the mace with which YOUR MAJESTY ordered it to be presented.

YOUR MAJESTY has most graciously, of your own Royal will and pleasure, given me the appointment of Surgeon to Your Majesty's Royal Hospital at Chelsea, the most honourable reward and retreat that can be bestowed upon a Military Surgeon.

In laying these volumes at YOUR MAJESTY'S feet, containing the principal labours of my life, in philosophical research, I beg to assure YOUR MAJESTY, that the asylum I enjoy, and the addition my income has received from Royal munificence, will induce, as well as enable me to devote the remainder of my life to the cultivation of Surgical Science for the benefit of mankind; in doing which, I trust that I shall prove myself not wholly undeserving of so many marks of Royal favour.

YOUR MAJESTY'S

Most devoted Servant,

EVERARD HOME.

Sackville-street, London,
July 10. 1823.

At a Quarterly Meeting of the Trustees of the Hunterian Collection, holden at the Museum of the Royal College of Surgeons, in London, on Saturday, the 3d Day of May, 1823,

PRESENT,

Lord St. Helens in the Chair.

Mr. Davies Gilbert.	Sir Everard Home.
Dr. Baillie.	Dr. Bright.
Dr. Ash.	Dr. Boyton.
Sir Humphrey Davy.	

Sir Humphrey Davy informed the Trustees, that Sir Everard Home, last Spring, had given a Course of Lectures on Comparative Anatomy, which formed a continuation of those given eight years since, and equally with the others contained Materials for a Catalogue raisonnée of many parts of the Collection; and, therefore, moved that Sir Everard Home be requested to publish such Lectures, in the same manner as he had done the others.

Resolved,

"That Sir Everard Home be requested to publish such Lectures accordingly."

EDMUND BELFOUR, Secretary.

INTRODUCTION.

Since these Lectures went to the press, new facts have come under my observation connected with many of the subjects upon which they treat.

This has led me to add an Appendix to this volume for their insertion; and that they may be connected to the Lectures to which they belong, there will be found in the *Table* of Contents, after the heads of the separate Lectures, a reference to the particular note in the Appendix.

This enables me to correct an erroneous opinion I had been led to adopt respecting the earth-worm, placing it among animals that mutually impregnate one another, instead of those that impregnate themselves.

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SYNOPSIS SYSTEMATIS REGNI ANIMALIS.

ERRATA.

Page 23 l. 9. for "prostrate" read *prostate.*
109 l. 17 for "a" read *no.*
243 l. 14 for "Kaleidoscope" read *Kaleidroscope.*
309. l. 5. for "antem" read *autem.*
356 l. 5 for "two ossa" read *double os*
371 l. 2 for "classes" read *orders*
502 l. 9 "10. The cup," &c. to be omitted.
516. l. 5 "61. Earth worm" to be omitted
— last line to be omitted.
519 add a line, 76. Isis.
521. l. 11 for "respirens" read *respirans.*
531 last line, for "agre" read *agri*
531. penult, for "Tectus" read *Tectum.*

Many of the references at the bottom of the pages are incorrect, but as the plates that belong to each Lecture are kept together, no great inconveniency can arise from such errors.

THIRD COURSE OF LECTURES,

DELIVERED IN THE

THEATRE OF THE ROYAL COLLEGE OF SURGEONS,

IN THE SPRING, 1822.

LECTURES

ON

COMPARATIVE ANATOMY.

LECTURE I.

On the Component Parts of the Blood.

It is nine years since I addressed an audience on the subject of Comparative Anatomy from this Chair.

During the whole of that period, I have continued to cultivate with ardour this branch of science, in which I was initiated, when only 17 years of age, under the Great Founder of the Collection that adorns this College.

At the advanced age to which I have now arrived, it is the height of my ambition, that the facts I have ascertained, and the observations I have made, which at present lie scattered over thirty-six volumes of the Philosophical Transactions, should be promulgated, to the Members of this College, before they meet the eye of the public in a regularly embodied form.

The benefit to be derived from them, I wish to be given, in the first instance, to our own body; and any credit, which I may be thought to have deserved, I am desirous to receive as one of the honorary professors of this Institution.

No small part of their value is derived from the numerous microscopical drawings of Mr. Bauer, which they contain.

That gentleman was engaged, for 30 years, under the late Sir Joseph Banks, in making drawings of the plants that were new to this country, as they came in flower in Kew Gardens; this could only be accurately done in the field of the microscope. So many years' experience in the use of that instrument have enabled him to attain a degree of excellence in examining and representing the smaller parts of animal and vegetable substances, which perhaps may never be equalled.

With the aid of such a man, whose mind has become enamoured, equally with my own, by the beauties met with in the pursuit of Comparative Anatomy, much was undoubtedly to be expected, and more has been already accomplished, than the promise of expectation could offer.

The microscope, it will be found, has done for Comparative Anatomy what the telescope had before accomplished for Astronomy; and the voltaic battery for Chemistry: it has, I may say, in an equal degree, enabled us to extend our inquiries beyond our predecessors; since we have, by its means, ascertained the mode of formation of the human ovum, and the exact state in which it is received into the uterus.

The stride that has been made by the microscopical observations of my colleague, who I am proud also to call my

friend, in extending our knowledge of the science of Comparative Anatomy, is already so great, that, unmindful of the advanced stage of life at which I have arrived, exceeding what was given to either of the Hunters, I shall continue to fill up those hours that are not occupied by my professional duties, in prosecuting these pursuits, instead of passing them in that repose, or those trifling amusements, in which old age is allowed to indulge.

It is this feeling, arising, I grant, from ambition, that has made me take advantage of being an honorary professor of this College, a second time to fill this chair; that I may promulgate, in a digested form, the mass of facts and observations, not included in the publication containing my former Lectures, so that these may constitute another part of a *catalogue raisonné* of the Collection.

As the capacity of one individual is rarely able to bring to perfection different branches of science, it is no wonder that, in the investigation of so complex a subject as the component parts of the blood, Hewson failed, Hunter fell short in the attempt, and Dr. Young, after the interesting discovery of the colouring matter being readily separated from the red globules, made no further advance. This view of these matters led me, at the time I ventured upon this enquiry, to engage, as my associates, Mr. Bauer, the accuracy of whose microscopical observations has been too long put to the proof, to admit of being disputed; and Professor Brande, whose chemical researches, and the judgment with which they have been pursued, are fully established.

Mr. Bauer, by his intimate knowledge of all the errors to which it may lead, has rendered the microscope, in his

hands, faithful to its office, although fallacious in those of others. He first considers the object, where the size admits of it, with the naked eye; then examines it, with lenses of small magnifying power; and when he has got thus far, compares with the nicest discrimination what was exhibited by one magnifying power, with what is shown by that immediately above it; and, where the appearances do not exactly correspond, employs the whole energies of his mind, with a patient labour, almost beyond what is natural, in ascertaining the cause of the deception, that in one of them had taken place. To the observations of such a man, upon subjects of this nature, if we are not confidently to place a reliance, how are we to give credit to the remarks that are made by common observers.

I have said thus much, as an introduction to the observations I am going to bring forward; that whatever opinion you may form of them, you may know they have been the result of long, and unwearied research; and have been so frequently repeated, as to afford proof of their correctness.

The red globules of the blood in the human body, enveloped in their colouring matter, appear, when measured in the microscope by a micrometer, to be $\frac{1}{1700}$ part of an inch in diameter; requiring 2,890,000 to a superficial or square inch. These globules, when deprived of their colouring matter, appear to be $\frac{1}{2000}$ part of an inch in diameter, which makes 4,000,000 of globules to a square inch. From these measurements, the globules, when deprived of the colouring matter, are not quite one-fifth part smaller. The colouring substance appears not to be contained in the globules, but only to envelope them: one reason for forming this opinion

is, that the separation is very rapidly effected; the colouring substance flowing from all parts of the globule at the same time. To retain the globules in the coloured state, it is necessary, that a very small quantity of blood only be smeared as thin as possible upon the glass, that all the moisture may instantly evaporate; they then preserve their colour and form, which is perfectly spherical. But if a greater quantity of blood be laid upon the glass, and the moisture retained only half a minute, the colouring matter begins, in a few seconds, to separate, and form a zone round the globule; and if the blood is diluted with water, the separation of the colouring matter is instantaneous.

When the globules in the human blood part with their colouring matter, they continue floating in the serum, and are seen to have an attraction towards one another, so as to coalesce, and unite.*

Having described the appearance of the red globules in the microscope, which are spherical unless in a compressed state, and having given the different measurements of these globules, both when enveloped in the colouring matter, and when deprived of it, in which last state they also form complete spheres, I shall now give the result of my labours, conjoined with that of my able associates, in the endeavour to prove that the human blood, in the act of coagulation, evolves a gaseous matter, which, as soon as it is disengaged, pervades the coagulum in every direction; passing through the serum in currents which become permanent tubes, and are immediately afterwards filled with red blood, when the circumstances in which the coagulum is placed admit of their

* Vide Pl. I. fig. 1, 2, 3.

being so. This new, and very important discovery, will form the principal subject of the present Lecture; after which, I trust, that, at our next meeting, I shall prove satisfactorily, that the different component parts of the body are all contained in the blood.

It has ever been a desideratum, to ascertain in what manner blood, after it had coagulated and remained at rest in different parts of a living animal, is rendered vascular. The fact itself has long been known to every enquirer into the operations of the animal economy; and several theories have been formed to explain it. Mr. Hunter, who perhaps understood the appearances such coagula put on, when injected from the neighbouring vessels, better than any other physiologist, was unable to trace a direct continuation of ramifying branches from the circumference of the living parts to the centre of the coagulum, and therefore referred it to a principle of life, existing in the blood, inherent in the coagulum which produced a series of vessels in every part of it, and these opened for themselves communications with the surrounding vessels.

Since Mr. Hunter's time, no more satisfactory opinion has been advanced, for the explanation of this curious phenomenon. I confess that my attention had not, for twenty years, been called to the inquiry, although, before that time, while I was assisting Mr. Hunter in the prosecution of his pursuits, I gave considerable attention to it, but remained unsatisfied with all the explanations that had been given.

My attention was however awakened to this subject, in the summer months of 1817, by different conversations I had with Mr. Bauer; in which, he told me, that to explain the

germination, and vegetation, of wheat, introductory to his illustrations of the diseases in corn, he sowed a quantity of wheat, and afterwards took up, every day, some grains, or plants for examination, till the ears were ripe. In his close attention to the changes that took place, he was very much struck with the rapid increase of the tubular hair of the root of the young plant of wheat, in its earliest stage of vegetation: and fixing his whole attention upon that part of the plant, he observed small pustules of a slimy substance, arising under the epidermis, on the surface of the young root; and in a few seconds, a small bubble of gas burst from the slimy matter, which extended in a moment to the length the hair was to acquire, and the slimy matter surrounding the gas immediately coagulated, and formed a canal.

He repeated his observations on another plant, whose pubescence consisted of a jointed hair, and observed the same effect take place; a bubble issued from the young stalk, and extended the slimy mucus to a short distance, forming the first joint, which immediately coagulated, and became tubular; at its extremity a new pustule of the same slimy mucus accumulated, from which, in a short time, the gas rushed; and thus, in a moment, a second joint was formed: in the same manner he observed the formation of the hairs of ten or twelve joints to take place.

These observations, so curious in themselves, and which explain, in so simple and satisfactory a manner, one of the modes in which tubes are formed in vegetables, and an addition made to the plant, impressed my mind so strongly, and so entirely engrossed my attention, that I did not allow Mr. Bauer to rest, till he gave me his assistance in instituting

experiments to ascertain, whether any thing similar takes place in animal bodies.

The first object of our inquiry was, to know whether any gas is to be found in the blood while circulating in the vessels; and under what circumstances it is separated. That the blood, whilst circulating in the arteries and veins, holds a considerable quantity of gas in solution, is proved by the following experiments, made at my request by Professor Brande. Blood was drawn from a vein of the arm, and, whilst yet warm, was placed under the receiver of an air-pump: as soon as the process of exhaustion was begun, there was a considerable escape of gas from the blood, so that it had the appearance of effervescing, and soon depressed the quicksilver in the gage of the pump. He afterwards ascertained that this gas is carbonic acid gas, equally met with in arterial and venal blood; and two cubic inches may be extricated from every ounce of blood.*

That a considerable portion of this carbonic acid gas is extricated from the blood, during the spontaneous coagulation of that fluid, was previously proved by Mr. Bauer; who filled glass tubes with blood, recently drawn, and tying them over with bladder, inverted them. At first there was no appearance of gas upon the surface; but as the blood coagulated, gas was separated; and in the course of twenty-four hours, was found in considerable quantity.

Having ascertained, not only the existence of gas in the blood, but that it is separated during the process of coagulation, I was most anxious to discover whether, as in vegetables, the gas, thus let loose, pervaded the surrounding fluid, into

* See Annales de Chemie, tom. xiii., for a confirmation of this statement.

which it is propelled, in any particular manner. With a view to determine this point, I wounded the skin of my arm with the point of a lancet, so as to draw a drop of blood, which was received into a watch-glass in a fluid state, and placed in the field of the microscope. The eye was then kept constantly fixed upon it, to watch the changes that might take place. The first thing that happened was the formation of a film upon the surface, the exposed part beginning to coagulate sooner than the rest. In about five minutes, something was seen to be disengaged in different parts of the coagulum, beginning to show itself where the greatest number of globules was collected; and from thence passing in every direction, with considerable rapidity, through the serum, but not at all interfering with the globules themselves, which had all discharged their colouring matter: wherever this extricated matter was carried, a net-work immediately formed of anastomosing tubes, pervading every part of the coagulum. When the blood was evaporated to dryness, the appearance of the net-work remained unaltered. In some instances bubbles were seen to burst through the film, upon the surface of the coagulum: this, however, did not prevent the ramifications that have been described from taking place.*

If the blood is cold when it is exposed in the microscope, and there is a larger quantity of serum upon the glass, the net-work is only formed in those parts where clusters of globules are collected; and when the serum dries, it cracks, and spoils the appearance. This happens sometimes several days after the formation of the net-work has taken place.

* Plate II. III.

When clear serum, without any globules, is put upon the glass, nothing is extricated; but when the serum is quite dry it cracks, and the appearance of these cracks may be mistaken for that of the net-work, but by comparing them, the difference becomes obvious.

Several of my friends, more deeply versed in the laws of mechanics than myself, to whom the above observations were communicated, remarked that, in their judgment, the micrometer used could give no correct notion of the diameter of a globule of the blood, as no spherical bodies can be accurately measured by that instrument. They were also led to have doubts of the appearance represented in the drawings of the coagulum being real, since air in all common circumstances, when let loose, forms itself into globules, not moving in straight or curved lines.

These objections coming from philosophers, for whose opinions on such subjects I have the highest respect, made me see, upon a little consideration, that I had left the investigation more imperfect than I had been aware of; since it is of very little consequence, whether in the act of drying coagulated blood puts on this particular appearance or not, if I cannot at the same time adduce proofs of the same changes taking place in coagula, while they are still moist, and also in the blood, when it coagulates in the interior parts of living animals.

I have, therefore, in consequence of these objections, instituted a course of experiments, the results of which, I hope, will do them away, by proving, that not only the conclusions I had come to were correct, but that the same process takes place in blood, when it has been extravasated in living animal

bodies, and that when that happens, there is immediately a communication opened between the tubes in the coagulum and the neighbouring arteries; the carbonic acid gas being absorbed by the blood, in those arteries, and the empty tubes filled with blood, to supply its place.

As the measurement of spherical bodies, is a subject on which my inexperience unfits me from being a judge, I requested my friend Captain Kater to have the goodness to measure the diameter of a red globule of the blood, in what appeared to him the most scientific manner, and to explain the mode of doing it. He kindly complied with my request; and the following is the mode which he adopted:—

" A ruler divided into inches, and tenths, was placed on " the box, which supports the microscope, a mother-of-pearl " micrometer scale was placed under the microscope, each " division of which was equal to one two-hundreth part of " an inch: viewing this with both eyes open, its image ap- " peared to be projected on the ruler, and one division " appeared to subtend the space of one inch. The micro- " meter scale being removed, blood sufficiently dilute was " placed under the microscope, and being viewed with both " eyes open, a globule of blood appeared to occupy, in the " first experiment, one-half of one-tenth of an inch; and " in the second experiment, one-third of one-tenth of an " inch upon the ruler. Hence the size of the globule by " the first experiment will be equal to $\frac{1}{2}$ of $\frac{1}{10}$ of $\frac{1}{200}$ of one " inch = $\frac{1}{4000}$ of an inch, the mean of which, or $\frac{1}{5000}$ of an " inch, may be considered as about the mean diameter of " a globule of the blood."

This measurement of Captain Kater's corresponds with that which has been made by Dr. Wollaston, by means of a very ingenious micrometer of his own invention, a description of which has a place in the Philosophical Transactions, and with the measurement of Dr. Young, in his eirometer, of which he has given an account in his work on medical literature.

The diameter of a globule of the blood, measured by mathematicians of such eminence, is to be set down as $\frac{1}{5000}$ part of an inch; and the diameter measured by the micrometer is $\frac{1}{1700}$ of an inch.

I have taken the more pains to have the difference between the measurement of a globule in these different modes ascertained, as it will enable microscopical observers like myself, unskilled in the higher branches of mathematics, to pursue their observations upon globular bodies, and continue to measure them in the micrometer, which gives us the advantage of examining the globules unpressed upon; therefore, without injury to their form, and although inaccurate in one respect, the simplicity of the mode employed will render that inaccuracy uniform. Such measurements may in all cases be afterwards compared with the mathematical methods, and thus have any error corrected.

To do away the objection which has been made to gas being contained in the net-work, formed in coagulated blood, I first made the following experiment. I placed a vessel nearly filled with blood drawn from the arm, under the receiver of an air-pump, and by exhaustion, extracted the gas contained in the blood. This blood deprived of its gas, when coagulated, exhibited no appearance of net-work.

When blood is drawn from the arm into a cup, and allowed to stand forty-eight hours, the serum is separated, and every where encloses the coagulum. The greater part of the surface of the coagulum is covered with small round holes, in which the gas had collected, and then forced its way out into the serum. But if blood taken by cupping is allowed to stand forty-eight hours in a cup, sometimes the serum is only separated in small quantity, and does not rise above the coagulum, in consequence of a film, or pellicle, forming on the surface of the coagulum, and fixing itself to the edge of the cup all round.

The pellicle, when examined at the end of forty-eight hours, appears to contain ramifying tubes. This arises from the mode by which the blood is extracted, depriving it of a part of its carbonic acid gas, and what remains is not sufficient in quantity to burst the pellicle; and when in the act of extrication it arrives at the under surface of the pellicle, it is forced to spread in different directions, putting on this appearance.

Having ascertained that this appearance of ramification is produced by the extrication of carbonic acid gas, I was led to make an attempt to inject a coagulum, under the receiver of an air-pump. The experiment was made in the following manner. A glass cup about an inch and a half deep, and nearly three inches in diameter, had blood from the arm drawn into it, till it was three parts full. The blood was allowed to stand in a cool place for forty-eight hours; the serum was strained off, and about $\frac{1}{6}$ part of the coagulum on one side was cut off and removed: the cavity thus made was filled with red size injection, in a fluid state, not, however,

quite so high up as the surface of the coagulum. In cutting off this portion, the edge showed the coagulum to be much weaker in consistence than it is commonly met with. The glass vessel was immediately put under the receiver of the air-pump. Very early in the exhaustion, the carbonic acid gas was evolved in such quantity, as to bring the fluid injection into a state of agitation, which had the advantage of keeping it fluid: when the exhaustion was increased, the evolvement of gas was so rapid, that it became necessary to work the pump very slowly.

After the exhaustion had become nearly complete, the glass vessel, with its contents, was removed, and with a view to fix and harden the coagulum the glass vessel was placed in boiling water, which was renewed at short intervals, carefully preventing the water from coming in contact with the blood.

This process melted the injection that had not passed into the coagulum, and allowed of its being poured off. The coagulum even now was by no means very firm, but capable of supporting itself: it was turned out upon a flat piece of glass, after having stood six hours, to make it dry more readily; and to prevent its going into putrefaction, it was divided into slices, half an inch thick. Forty-eight hours after it had been injected, I examined it with Mr. Bauer, and found its internal substance very minutely injected, there being only two small bursts of extravasation, each of the size of a pea. This experiment decides the question respecting the structure of the net-work; since when the tubes are filled with injection, their shape, size, and mode of ramification admit of being examined: one of the slices of the coagulum, in

which this structure is seen, I have been able to preserve in spirit, two others in oil of turpentine, so that the originals, as well as the drawings, are brought before my audience.* As the injection could only fill the spaces from which the carbonic acid gas was extracted, it cannot be doubted that the tubes were formed by the gas.

Having brought these facts in proof of tubes being formed by evolvement of carbonic acid gas contained in the circulating blood, it next became necessary to ascertain, whether coagula of blood, deposited in the internal cavities of the living body, underwent the same change. To determine this point, I wounded one of the smaller branches of the mesenteric artery of a rabbit, and the wound in the abdomen being closed, it was allowed to bleed into the general cavity. In forty-eight hours, the animal was pithed, and the arteries of the abdominal viscera injected with minute injection, coloured by vermillion.

The cavity of the belly was afterwards opened: it was in a perfectly natural state: there was no adhesion of parts: the small intestines were very vascular, and the vessels minutely injected. No serum was met with, nor large coagula of blood. A very small one was found lying upon the peritonæum in the right iliac region, and partly adhering to it; but not by the whole surface of contact. This coagulum had its tubes evidently injected, and on that account was the only one I particularly examined, although there were two smaller ones lying upon a portion of the intestinum ilium. All the rest of the blood effused had been absorbed. The small arteries of the peritonæum are seen to have

* Vide Plate IV.

entered the tubes in the coagulum, which are larger than the arteries with which this communication has been formed; and their appearance is very different from that of arteries: they seem to have been over distended by the injection, and not to have acquired a regular form: there are three or four points of communication laterally between the tubes in the coagulum and the arteries of the peritonæum, and it would appear that there is another immediately behind the centre of the coagulum. At all these points the smallness of the arteries, when compared with the tubes themselves, is equally distinct.*

The appearance this injected coagulum puts on brought to my recollection a preparation I had made in the year 1788, in which a small pedicle of coagulable lymph adhered to the surface of a portion of intestine, and had become vascular, in less than twenty-nine hours, since the person died in that period after the operation for the strangulated hernia; and at the time the intestine was returned, it had the natural polish on its surface. I had succeeded in injecting the arteries leading to it. An account of this case is published in the Appendix to my work upon Ulcers; and a drawing from the preparation is engraved in Mr. Hunter's work upon the Blood, Inflammation, and Gun-shot Wounds, but from not being magnified, the parts are indistinctly seen.

I requested Mr. Bauer to examine this preparation, which is preserved in the Hunterian Collection of Morbid Anatomy, and to make a magnified drawing of it, upon nearly the same scale as that of the coagulum of blood, to show the difference, if there is any, between the appearance of the tubes formed in

* Vide Plate V.

exuded coagulable lymph, and extravasated blood. He has done so, and they correspond in the most essential particular, which is, that the canal in the coagulum is larger in diameter than the artery by which it is supplied with blood.*

By this means, I have been enabled to show the appearance these tubes put on, both in coagula of blood extravasated into the cavities of living animal bodies, and in exudations of coagulable lymph, at nearly the shortest possible periods in which they can be formed.

There is a preparation in the Hunterian Collection, of a coagulum of blood lying upon the testicle, of considerable size, which was produced by wounding an artery in tapping a hydrocele; and from the circumstance of the testicle being extirpated a month afterwards, it was ascertained, that the coagulum had remained there four weeks before the extirpation. The parts, immediately after the operation, were injected by Mr. Hunter, and the coagulum was found to be vascular. This is the most satisfactory proof of coagulated blood having vessels Mr. Hunter had met with. He has given several engravings of the coagulum in his work on the blood; but from Mr. Bell not having had Mr. Bauer's knowledge of drawing such objects, in a magnified state, little information is to be received from an examination of the engravings. It occurred to me, that by a re-examination of this preparation, and making a thin section through the coagulum, and continued into the substance of the testicle, Mr. Bauer might be able to make a magnified drawing, which would enable me to show what changes are produced in the appearance of the tubes, after they had for so long a

* Plate VI.

time continued to receive the circulating blood; and whether the arteries in that period became so much enlarged as to convert these tubes into subordinate branches. The tubes were found to have acquired a distinct outer coat, that admitted of being separated from the lining, showing the tubes to have become regular vessels, but they still remained larger than the branches of the arteries, by which they were supplied with blood.*

These, gentlemen, are the proofs upon which I have endeavoured to establish this new doctrine, explanatory of many of the most important processes that take place in the animal economy. Trusting that they are sufficient for that purpose, I shall not detain you longer upon this subject. It may fix the various new facts that have been stated more strongly on your minds, by showing in a regular series Mr. Bauer's microscopical drawings, by which they are elucidated.

These will be met with by the reader, in the volume of plates.

* Plate VII.

LECTURE II.

The discoveries contained in the last Lecture, respecting the nature of the blood, having opened a new field of enquiry, into the materials of which that fluid is composed; and the microscope appearing to be capable of giving considerable aid to our further researches, I requested Mr. Bauer to give us his assistance, in prosecuting so interesting and curious an investigation.

Hitherto the blood had been considered as made up of red globules, suspended in serum. Dr. Young had discovered that the globules and the colouring matter were distinct from each other; and Mr. Bauer has shown that the red globules, when deprived of their colouring matter, are 1-5th less than they were before.

As the tubes formed in the serum by the evolvement of the carbonic acid gas do not any where include these globules, it became a subject highly deserving of investigation to ascertain what part of the serum becomes the covering of those tubes so formed; which, till they were known to exist, could not in any way have become an object of enquiry.

I shall therefore now proceed to show, that the blood is composed of many other materials which have hitherto entirely escaped observation. My former experiments were

made upon coagula, recently formed from the blood, whether out of the body, or in the interstices, of parts possessed of life.

Upon the present occasion, I have taken an opposite course, and have examined the coagula formed in aneurismal tumours. It is to be understood, that in this disease of the arteries, the coats yield to the impulse of the heart, and admit of being permanently dilated, so as to form a pouch, in which the blood that is admitted to remain at rest coagulates. This dilatation is gradual; and as the pouch enlarges, the coagulum is found to be made up of a succession of layers, affording an opportunity of observing the changes coagulated blood undergoes, in such circumstances, at different periods of time.

In the examination of the section of an aneurismal tumour in the microscope, Mr. Bauer found, that the layer of coagulum, in contact with the blood in circulation, was red in its colour, loose in its texture, and principally consisted of red globules; from which the red colour had been discharged, and the colour was now seen diffused through the mass. Besides these globules, he saw others, of a smaller size, which he had never met with in fluid blood, however frequently he had examined it; there was also a small quantity of a transparent elastic mucus, insoluble in water. The new discovered globules measured in the micrometer were $\frac{1}{2800}$ part of an inch in diameter, and their number in proportion to the large ones as one to four.

The other layers, in proportion to the length of time coagulation had taken place, were become paler in colour, denser in texture, and, what is most particularly deserving of

notice in the present investigation, the proportion of the small globules to the large ones gradually increased, and in the layer longest coagulated they were as four to one. In this layer, there was also the largest proportion of the transparent elastic mucus.

The coat of the artery, forming the pouch, appeared to be made up of zig-zag, or serpentine fibres, connected by the elastic mucus, in which many of the small globules were detected.

The condensed cellular membrane on the outside of the pouch consisted of thin membranes or films, easily separated, and between them were found many small globules.

In the section of a large aneurismal tumour, a deposit of crystals was met with.

This uncommon appearance is represented in the annexed drawings.* These salts, in the absence of Professor Brande, were analyzed by Mr. Faraday, assistant in the Laboratory of the Royal Institution. They contain sulphate of lime, with muriate and phosphate of soda; salts, usually met with in the blood, but probably never before seen in the form of crystals.

The discovery of small globules in aneurismal coagula, and the increase of their number, in proportion to the duration of the coagulum, throws great light upon the composition of the blood.

Till this discovery was made, we knew of no globules in the blood, but the red globules, either enclosed in their colouring matter, or deprived of it; indeed these smaller ones, being held in solution in the serum, are only brought

* Plate VIII. fig. 1, 2, 3.

to view by the act of coagulation; and under the same circumstances we find the salts crystallize.

To ascertain whether these small globules constitute the substance thrown out in inflammation, Mr. Bauer examined a small portion of a mass of coagulable lymph, taken from the vagina of an ass, where it had been deposited by a violent attack of inflammation; and another portion, from the internal surface of an inflamed vein.* He found both substances made up of the small globules just discovered, mixed with a few red globules, deprived of their colouring matter. These globules were met with in former experiments, and were believed to have been newly produced from the serum, but are now found to be the same as those which had been held in solution in the serum, and afterwards separated.

The globules found by Basilius in the serum, after filtration through paper, must have been of the same kind, and mistaken by him for blood-globules. In the prosecution of this enquiry, I procured the coagulum of some highly inflamed blood, as it is termed. The buff was very thick and firm, the lower portion loose in its texture. Mr. Bauer found the buff to consist almost wholly of the small globules, which I shall now call *lymph-globules*, and the lower portion principally of red globules; so that the buffy appearance occurs when the lymph is unusually slow in coagulating, and the red globules, which are so much larger and heavier, sink before the process has taken place.

* Both of these preparations are described in Mr. Hunter's work upon the Blood, Inflammation, and Gun-shot Wounds, and for that reason were selected, as the identity of their being composed of coagulable lymph was already established.

In the absence of Professor Brande, Mr. Faraday analyzed a portion of the buff, as the upper part is termed, and of the lower part, made up of red globules, having previously washed away the colouring matter: their chemical properties he found to be in all respects the same.

That I might compare the structure of tumours with that of the layers in aneurismal coagula, I got Mr. Bauer to examine in the microscope the structure of a tumour, in the prostrate gland, made up of rounded nodules. The last formed of these was produced by the bursting of a small artery, in the substance of the gland, so short a time before death, that the rupture of the vessel was distinctly seen when the parts were examined. He found the texture of the tumour soft and spongy: it was made up almost wholly of red globules, free from colour, very few of those of lymph, and some of the transparent elastic jelly: the bands between the nodules were composed of three-fourths of lymph, one-fourth of red globules, from which the colour had been discharged, and a considerable proportion of the transparent jelly.

A tumour in the breast, of long standing, of which the first formed part was hard and colourless, the last less compact, and full of vessels or tubes, is shown in the annexed drawings.

When its structure was examined in the microscope, the first part was made up almost wholly of lymph-globules, and elastic jelly; the last made one-fourth of the whole. The soft part consisted only of about one-fourth of lymph globules, the rest being red globules which had lost their colour.*

* Plate IX. fig. 1, 2, 3, 4, 5, 6, 7.

The structure of such tumours is nearly allied to that of the layers in an aneurism. The layers in an aneurism do not, it is true, like the tumours, become vascular, since, at the time the blood in aneurism coagulates, the coagulum is in contact with the circulating blood into which the carbonic acid gas escapes as fast as it is evolved.

To ascertain whether the proportion of carbonic acid gas in the blood is liable to vary, according to the state of the blood, a very buffy coagulum was placed in the receiver of an air-pump, with a syphon passing from the vessel containing it into a bottle filled with barytes-water. The pump was worked, and the gas came over in single bubbles, which occasioned a precipitation of carbonate of barytes, proving this gas to be carbonic acid. From a less buffy coagulum the gas came over in several bubbles at a time.

When there was no buff the gas was abundant, and the precipitation in the barytes-water copious. To ascertain whether this gas has its origin from the food in the process of digestion, a pauper from one of our workhouses, an hour after eating a hearty dinner, and drinking a pint of porter, was bled at the arm to six ounces. The coagulum was treated in the same manner as the others in the air-pump, and at the same distance of time, from its being drawn, the gas passed through the syphon in a torrent, and there was a proportionate precipitation.

Professor Brande finds carbonic acid gas to be commonly met with in the urine; and in greater quantity immediately after a full meal.

The source from whence the carbonic acid gas is supplied having been thus determined, an attempt was made to trace

the lymph globules and red globules, to their origin, by examining in the microscope the digestive organs. The pyloric portion of the stomach, and the duodenum were found to contain a glary mucus. In this mucus Mr. Bauer found a great number of lymph globules, and a smaller number of red globules without colour, so that such globules appear in the stomach during the earliest stage of digestion; but are probably deposited from the blood-vessels.

In the human species, the produce of the process of digestion becomes white, and therefore is readily distinguished from any other fluids; in general it is first met with in this state in the beginning of the jejunum, but sometimes along the whole course of the duodenum. The readiness with which this substance is absorbed, and the velocity with which it is carried along the lacteal vessels, make it difficult to procure enough for examination in those vessels, or before it reaches the glands in the mesentery, through which it must pass before it arrives at the thoracic duct.

An opportunity occurred of making this examination upon the contents of the mesenteric glands, of a man who had died in a fit an hour after having eaten his dinner. Mr. Bauer having extricated some of the glands of the mesentery from the surrounding fat, and cellular membrane, divided them transversely; when a quantity of milk-white fluid issued out. On examination the white colour of this fluid was found to depend upon an infinity of white globules, floating in a clear, perfectly colourless fluid, in the same manner as the red globules do in the serum. About eight tenths of these globules varied in size from the smallest speck, to the size of the lymph globules, about one-tenth

were of the size of red globules deprived of the colouring matter. When this fluid was left a few minutes on the glass, not only many new globules were formed, but the original small ones visibly increased on the field of the microscope, not by several globules uniting, but by an accession of substance; and he watched several that enlarged to the full size of blood globules, inclosed in their colouring matter; in that state they appeared more opaque: and when the glass was laid upon black paper, they appeared as distinctly to be milk white; as the globules of the blood, when the glass is laid upon white paper, appeared to be bright red.

When the fluid is diluted with water, no additional globules are produced: and the large ones are reduced in size, in the same manner as the red globules are, when their colouring matter is dissolved, and is leaving them. When there is a sufficient quantity of the fluid left to evaporate, ramifications are formed in every respect as distinct as those shown in the preceding Lecture, in the magnified drawing of a drop of human blood, in the state of coagulation.

From the observations Mr. Bauer has had the opportunity of making upon the contents of the lacteal glands, he is satisfied that the red globules of the blood acquire the globular form in these glands; and that afterwards, so far as respects their external appearance, no further change is necessary, but their becoming red.

As the exposure of the blood to the air in its passage through the lungs, restores the brilliancy of colour that is lost in the circulation through the body, we can have no doubt that it is in the vessels of the lungs, that the blood receives its hue.

The gradual discovery of so many different ingredients in the blood, led me to believe, that all the materials composing animal bodies, are contained in that fluid; and indeed there are only two with which I am acquainted, that have not already been shown to exist in it. The one is a transparent elastic mucus soluble in water, met with in the brain, and which will be noticed in a future Lecture, the other is animal oil.

The last of these, although I have made several experiments for that purpose, I have been unable to detect. This, however, is of less consequence, oil being an ingredient in the blood of fishes, as the skate and salmon: and the alkalie in the human blood, prevents oil from being detected in that fluid.

In the skate's blood the globules are very large, of an oval form, the colouring matter yellow; they very readily change their appearance. When decomposition begins to take place the oval becomes flattened, the central part appears more dense than the margin, which surrounds it like a ring, and when this ring dissolves, the middle globules of a spherical form are left in the surrounding fluid, in which oil is distinguishable to the naked eye. The globules are represented magnified 400 diameters.

Salts are found crystallized in the serum; they are magnified 200 diameters.*

To ascertain whether this transparent elastic mucus, soluble in water, is contained in the circulating blood, the following experiment was made:—

Two ounces of blood were drawn from the arm, and

* Plate XXXIII. fig. 5, 6.

allowed to remain at rest in a phial till all the serum separated, which required thirty-six hours; the serum was poured off, and the phial filled up with distilled water. In twenty-four hours the upper part of the coagulum, particularly at the edges, became tumid; apparently from having imbibed some of the water, this part was semi-transparent, and of a light red colour. A small portion was cut off and put into a saucer with distilled water, covered over by a watch glass. In twenty-four hours, carbonic acid gas was seen in bubbles round the edge of the watch glass, the colouring matter had mixed with the water, and the whole of the substance was nearly dissolved.

From this experiment confirmed by others, this mucus is not only present in the blood, but proves to be the medium connecting the colouring matter to the globules, and therefore, when red globules are put in water, they lose their colour, the medium dissolving by which it was attached.

From what has been stated in the present Lecture, the blood, besides the red globules and the serum, contains an elastic transparent mucus soluble in water, apparently the medium by which the globule receives its colour, while exposed to the air in the lungs: and when the red globules are exposed to water, the solution of this medium deprives them of their colour, which is deposited in the water.

We have already shown that there are globules of a smaller size, than those of the blood, which are in solution in the serum, and become the coverings of the tubes, formed by the extrication of the carbonic acid gas.

Besides these, we have an elastic substance, which is not soluble in water, and is employed in all ligamentous and muscular structures of the body; for in every muscle, as I

explained in my former Lectures, there is a large proportion of elastic matter, and the presence of oil and salts, in the blood, has been sufficiently ascertained. The facts I have brought forward respecting the component parts of the blood, appear to me sufficient to warrant the conclusion, that all the materials, of which an animal body is composed, are to be met with in the circulating blood; but so modified and combined, as not to be detected without decomposing the blood, and having the assistance of microscopical observations.

Were these Lectures only for the instruction of the philosopher, the naturalist, and physiologist, I would here close my investigation, into the nature of the blood: but surrounded as I am by the members of this College, whose duties are of a much higher order than simply the studies of anatomy and physiology, since they are called upon to direct the treatment of all cases of injury to the human body, so that the repairs of such injury may be carried on in the best possible manner, and receive the most prompt assistance that art can afford. This is not all: for the high pre-eminent situation in the profession which the members of this College hold, points them out as patterns of excellence for the guidance of others, who have not had the same insight into knowledge, and therefore must look up to them for instruction.

Delivering these Lectures to such men, I am called upon to proceed, and point out what parts of the blood are employed in such repairs, to follow up the observations I have made, and apply them to the practice of surgery.

To explain that the red globules, deprived of their colouring matter, are the materials of which pus is formed, and,

therefore, that pus is no longer to be considered as a secretion from the blood, but a principal part separated from the general mass for the purpose of producing new flesh: that, in this process, the first step is coagulation; the next, the extrication of carbonic acid gas; the third, the smaller globules composing coagulable lymph, being separated from the serum, and forming the tubes from which new blood-vessels are produced.

These are facts of considerable importance in practical surgery: for when it is once known, that coagulated pus can become vascular, similar to coagulated blood, we have arrived at the principle on which granulations are formed, and from whence they derive the power of contraction, which is found to be inherent in them; we also can account for the great advantage of compression upon the surface of sores, since by that means all the superfluous pus is removed, leaving only enough to form the coagulum.

In a dissertation on pus, first published in the year 1788, before these new lights were thrown upon the animal economy, I was led to believe that fluid to be a secretion from the ends of the arteries; that in its first appearance, it was transparent, and after it had been deposited on the surface of the sore, it underwent changes; the first of these was the formation of small globules, which afterwards enlarged, into pus globules. I was led into this error by the following circumstances. The first appearance upon the sore, I found to be serum; this on exposure, had its thinner part evaporated, and the lymph globules which it held in solution, were deposited: soon after, the smaller arteries poured out the blood globules, deprived of their colouring matter, and

formed the materials of pus. I was very naturally led, when they appeared, to consider them to be produced from what had already been retained under my eye. To watch over, and ascertain the processes of nature, we find more is necessary than patient observation. For that purpose, it requires long and persevering experience, as well as skilful microscopical observers.

Before I attempted to trace the changes met with in pus, as it appears upon the surface of a sore, my first object was, to become accurately acquainted with the appearance of the surface, immediately under the newly formed pus. That this surface might be examined under the most favourable circumstances for this purpose, I selected an ulcer upon the leg, to which no application had been made but straps of adhesive plaster, and these only once changed in twenty-four hours; and the time of change was chosen for the examination, and a double convex lens, magnifying about eight times, was employed. Previous to the adhesive straps being taken off from the sore, the leg was laid upon a low table, so as to be immediately under the eye, and in the position in which hæmorrhage from the small vessels was least likely to take place, and obscure the surface of the sore.

That the accuracy of these observations might be ensured, I got another person to look at the sores, as well as myself, upon every occasion on which they were examined; and no change is mentioned to have taken place, that was not distinctly seen by us both. A healthy sore thus examined, had the following appearance: the surface was uneven, being made up of eminences and hollows. The eminences, consisted of small clusters of tortuous blood-vessels: the

hollows were filled with pus. After remaining exposed from five to ten minutes, the following alterations were distinctly seen to take place: a very thin pellicle covered the whole surface; this was so transparent, that a number of small bubbles of gas were seen to make their appearance under it, n different places; in a few minutes more, horizontal tubes of different sizes filled with red blood, taking different directions, and anastomosing with one another, were seen to form. In some places there were red points, the termination of perpendicular tubes, that had been stopped in their course by coming against the pellicle.

There were also occasional specks of extravasated blood, from some of the horizontal tubes bursting through the pellicle.

These changes seemed to occur in a regular order of succession. First, the pellicle was formed on the surface. Secondly, the bubbles of gas made their appearance. Thirdly, the tubes filled with red blood were observed; these, while filled with carbonic acid gas, were not to be distinguished from the semi-transparent jelly which surrounded them.

If under these circumstances the foot was put to the ground, so weak was the covering of the tubes that it instantly gave way, and the sore was covered with blood.

As it is difficult to describe appearances of this kind, and it is of importance that the fact of such appearances being met with, should be well established, I requested Mr. Bauer to make a drawing of a portion of the sore, of which I have attempted a description, after it had been exposed for nearly sixteen minutes: and on the following day, he made a drawing of the same portion, not only shewing the progress that

had been made in healing in twenty-four hours, but that the canals formed on the first day had, on the second, become permanent tubes, and were covered over by cuticle.*

It is so easy for any one to bring the facts I have stated under his own observation, that I shall leave them to speak for themselves; but it may appear that farther evidence is required to establish the doctrine, that these changes are produced entirely by the coagulation of the pus, and the evolvement of the carbonic acid gas. To remove every objection which it occurred to me could be made, I put the doctrine to the test of the following experiments.—Immediately after the exposure of the surface of the sore, I poured water at the temperature of 95° upon it, which washed away all the pus; and although the sore was left exposed in this state ten minutes longer, none of the above-mentioned appearances were produced; so that the presence of pus seems necessary to their taking place.

As cold water has a power of coagulating pus more rapidly than simply exposure to the atmosphere, I applied water at the temperature of 65° to a sore; and all the appearances were produced in so much greater a degree, that I requested Mr. Bauer would make a drawing of a portion of a sore that had been exposed for fifteen minutes under common circumstances; and at the end of that period, to pour upon it water at the temperature of 65°; and in ten minutes more, begin a second drawing of the same surface, showing to how much greater an extent the appearances had taken place; by this means proving, that the degree

* Plate X. fig. 1, 2.

of coagulation, was the great cause of the effects that followed.*

As a saturated solution of sal-ammoniac has a greater power of coagulating pus than any substance that I am acquainted with (and on that account, in the year 1788, I recommended its mixture with pus as the best criterion by which pus might be detected and distinguished from other animal fluids), I now determined to try what effect it would have, with respect to the appearance of the granulations; for although in some respects it is not a fair trial, since the chemical combination of pus with this solution might destroy the natural properties of pus, and convert it into a compound of a very different kind, still that was by no means necessarily the case.

Upon pouring a saturated solution of sal-ammoniac, at the temperature of 45°, upon the surface of a sore, the pus almost immediately became curdled, and tortuous canals were every where seen in these masses of coagulum. There was great uniformity in the tortuous canals; they were of the same size, running first in a straight direction, terminating in a spiral turn and a half, the end of which was extremely small; they were all filled with red blood. It was remarked, that although the canals themselves were in greater number, there were fewer bubbles of gas than when the cold water had been used, more having been retained in the tubes. Some of the coagula of pus were more elevated than the general surface; and large tubes filled with red blood, were seen superficially passing over some of them, without any smaller ones in the immediate neighbourhood. To ascertain

* Plate XI. fig. 1, 2.

whether there was any vascular basis with which these tubes were connected, I passed a tolerably large crooked needle under one of them, bringing out the point on the opposite side, so that the tube was distinctly seen above the flat surface of the needle: I then withdrew it, and there was not the slightest degree of extravasation of blood. This was repeated on several different sores, without any appearance of blood escaping, or the person having the slightest pain: affording a sufficient proof of the tubes being formed in the coagulated pus, immediately on its coagulation, before any other approximation to living animal solids had taken place.

The readiness with which the blood displaces the carbonic acid gas contained in these tubes may be explained by the great disposition the blood has to absorb this particular gas, which forms so large a proportion of its component parts.

I shall not take up the time of my audience with a farther detail of experiments, although many more were made, as the results were uniformly the same.

If I have succeeded in establishing the formation of granulations to depend on the coagulated pus being rendered tubular by the extrication of its carbonic acid gas, and that these tubes, or canals, are immediately filled with red blood, and thus connected with the general circulation, there will be little difficulty in making out the succeeding changes, by means of which the coagulated pus afterwards becomes organized; since Mr. Bauer's drawings, laid before my audience in my former Lecture, trace the thin covering of the tubes in the coagulated blood to the thick arterial coats met with in the testicle, after the coagulum had remained a

month in that situation; and it is fully established that the arteries build up all the different structures in the body, as well in the restoration of parts, as their original formation acting under the agency of the nerves.

The further prosecution of this enquiry belongs wholly to the department of Surgery; but as the explanation which I have given of the process employed in the regeneration of parts is, I believe, entirely different from that which is generally received, I have been desirous of pursuing such changes thus far in these Lectures.

LECTURE III.

On the Brain and Nerves.

ANY attempt to come at a knowledge of the materials of the Brain without a previous acquaintance with the component parts of the blood, was not likely to be attended with success; and it was only after Mr. Bauer's analysis of the blood, that I ventured to request that he would apply his microscopical observations to the brain, not doubting that they would be attended with the same success; and I shall now explain the observations he has made upon this, the most important organ of the human body.

If the mass of the brain is kept in water for forty-eight hours, and a thin slice is cut from the medullary part of the cerebrum, and laid upon a glass plate previously wetted with water, and a drop of water is allowed to fall upon the slice, holding the glass a little obliquely, so that the water must run across the surface of the glass, the force with which it moves is sufficient to break down the medullary substance of the brain; so as to bring distinctly into view, innumerable loose globules, many fragments of fibres of single rows of globules, and bundles of fibres, some of them of considerable length.

If a portion of the substance of the brain is laid upon a piece of dry glass, and the separation of its parts is attempted by instruments, it is impossible to effect it, as the viscid mucus contained in it adheres strongly to the glass, in the manner of pigment, a state in which the globules are not discernible.

It is impossible to distinguish the fibres composed of globules, in an opaque state of the substance; for, although in the section of any part of the brain, by means of a very strong magnifying lens, lines are discernible, these lines are produced by the light and shade on the substance, and only denote the bundles of fibres of which the brain is composed; but not the fibres of simple globules.

The gelatinous mucus seems to dissolve readily, and mix with the water; and, being perfectly colourless and transparent, is entirely invisible, while the substance of the brain is fresh, or whilst it is immersed in water: but if the water is left to evaporate, and the substance gets dry, the mucus collects round the loose globules and fibres in considerable quantity; or forms irregular flakes or splotches upon the glass, perfectly transparent, and of a yellowish tinge.

If a portion is cut off from the brain in a fresh state, before it has been put in water, and laid upon a dry glass plate, and covered by a cup, so as to prevent evaporation, a perfectly colourless aqueous fluid is exuded; which evaporates on exposure to the air, and hardly leaves any mark upon the glass.

The cortical substance of the cerebrum contains also a fluid resembling the serum of the blood: it has a yellower tint than the fluids in the medullary substance, or any other part of the brain; and, when dry, it assumes the same

glassy appearance, and cracks in the same way that the serum does when dried on glass.

The above are all the visible materials that can be distinguished in the different parts of the human brain by means of the microscope: and, making allowance for slight deviations, are the same in different parts of the organ.

The globules are from $\frac{1}{2400}$ to $\frac{1}{4000}$ of an inch in diameter; but the general or predominant size is $\frac{1}{3200}$. They are semi-transparent, and of a white colour, arranged into fibres of single globules, and seem to be held together by the viscid mucus. The fibres are formed into bundles connected in the same way.

The principal difference in the appearance of the different parts of the brain consists in the size of the globules and the proportions they bear to the other parts: as, for instance, the cortical substance of the cerebrum and cerebellum, (which are in all respects alike) consists chiefly of globules from $\frac{1}{3200}$ to $\frac{1}{1000}$ of an inch in diameter; and in quantity the smaller globules prevail. The fibres of single globules are not so readily distinguished here as in the other parts of the brain: the gelatinous mucus and fluid, resembling serum, are very abundant. The finest and most delicate branches of the arteries and veins are only found in the cortical substance.

The medullary substance of the cerebrum and cerebellum differs from the above in the number of large globules prevailing; the mucus being more tenacious, and less in quantity in proportion to the globules, and the single fibres being more distinct, and the arterial and venal branches being larger.

The crura cerebri and cerebelli resemble in general the medullary substance, only that the mucus and fluids are more abundant; and there appears a greater proportion of mucus than of globules; the blood vessels are larger than in the medullary substance.

The medulla oblongata, the corpora pyamidalia, and olivaria, have nearly the same structure as the medullary substance; the single fibres, and their bundles, are composed of the larger globules: the mucus, however, is very abundant, and is sooner dissolved in water than the mucus in any other part of the brain.

The pons verolii is principally composed of globules of $\frac{1}{3200}$ of an inch; the fibres not quite so distinct as in the medulla oblongata; the mucus very abundant. The medulla spinalis has the globules of $\frac{1}{2400}$ to $\frac{1}{3200}$ of an inch predominant; the mucus and fluid less tenacious, but in greater quantity than in any part of the brain: for this reason, the single fibres are not so readily discovered; for if the part is not sufficiently soaked in water, they cannot be separated; and if macerated too much, the whole is dissolved into a mass like cream. The corpus callosum resembles the medulla spinalis, but contains a greater quantity of globules of $\frac{1}{2400}$ of an inch than any other part of the brain: the quantity of mucus and fluid are at least equal to the mass of globules.

Every part of the substance of the brain is pervaded by innumerable blood vessels, which are of considerable size towards the centre, but branch out to an extreme degree of minuteness, even less than the half diameter of a red globule with its colouring matter; and although reduced to that size, the fluid they carry is red.

These arteries in the brain never anastomose, but do so in the retina; their branches are accompanied by vessels of still less diameter, having valves. The valves are at very short distances, particularly near their extremities; and when the brain is fresh, these vessels contain a red fluid.

The circumstances noticed by Mr. Bauer, namely, the cortical substance of the cerebrum and cerebellum being made up of the small globules, containing the gelatinous fluid, soluble in water in great abundance, and having branches more minute than the other arteries of the brain; also the corresponding vessels having valves similar to absorbent vessels, and their canals carrying a red fluid, throw considerable light upon the functions of the brain, and show that the cortical substance is a very important part of this organ; although the pons varolii, from being the commune vinculum between its different portions, may be the most essential to life.*

The minute vessels supplied with valves, must perform the office of lymphatics; the smallness of their size accounts for their not having been met with before in this organ: these vessels carry the absorbed matter into the superior longitudinal sinus, which appears more a reservoir than a vein, for the fluid that passes through it is commonly as black as ink, a change we shall find the blood undergoes when decomposed.

The superior longitudinal sinus may be considered as the common trunk of the absorbents of the pia mater; from its triangular form, it always remains full. The aqueous liquid,

* Vide Plate XII.

by which the ventricles are filled, varies in quantity, and thus answers the purpose of equalizing internal pressure.

As the transparent mucus is not only one of the most abundant materials of which the brain itself is composed, but is the medium by which the globules of the retina are kept together, and serves the same purpose in the medullary texture of the nerves, there can be no doubt that the communication of sensation and volition, more or less, depends upon it. And it would appear from the following case, that when terminations of nerves are covered with this mucus, it partakes of their sensibility.

A lady had a wound on the breast in a healing state, a prominent speck of a black colour suddenly made its appearance on the surface; it was tender beyond expression to the touch; next day it disappeared, and the tenderness was gone. The speck must have been this jelly coagulated upon the termination of a nerve, and therefore the impression made by touching it was communicated to the nerve; but when it was absorbed, the nerve received a coating of coagulable lymph, and there was no more pain.

Mr. Hunter's comprehensive mind grasped at the idea of the existence of something of this kind, although he had not arrived at a knowledge of the substance employed to produce the effect. He said, that so wonderful was the connection between the brain and every structure of the body, that it was to be explained in no other way, than by considering that the materia vitæ was every where in one of two forms, collected into one mass in the brain, which he called coacervata; and diffused through the body, which he called diffusa, and the nerves communicated between them.

From Mr. Bauer's microscopical examinations of the medullary structure of the brain, the variety in the size of the globules, and in the consistence of the uniting medium, it becomes evident that very different functions are performed by these various structures.

The human brain it is not requisite for me to demonstrate to my present audience: I trust that its general form is familiar to you all. It is only necessary to point out which of its parts bears the largest proportion to the others, and exceeds the dimensions of the same part of the brain in animals; for such part must be considered as that which gives man the superiority in intellect. This will be found to be the cerebrum. Next in proportion to that of man, is the cerebrum in the more sagacious animals, as the elephant; and on the contrary, the rhinoceros, which in all ages has been admitted to be the most stupid of quadrupeds, has a skull so small in its capacity, that when compared to that of the elephant it is as 35 to 182.

The following account of the habits of the Asiatic rhinoceros with the welted hide, which died after being kept three years in Exeter-'change, I received from the keeper who had the care of it during the whole of that period.

About a month after it came to the menagerie, it endeavoured to kill the keeper, and nearly succeeded: it ran at him with the greatest impetuosity, but fortunately the horn passed between his thighs, and threw him upon the animal's head: the point was forced into the wooden partition, so as not to admit of being withdrawn, before the keeper had time to escape.

The skin at the edges of the scales which form its covering, is very sensible, and the mode used to manage the animal was by a short whip with a lash; but frequently, and more especially in the night, fits of phrenzy came on, during which nothing could controul its fury; in these he played all kinds of antics, made hideous noises, and knocked every thing to pieces. It had no choice of food, ate ravenously all kinds of vegetables, and even its own dung, and spread it over the sides of his den. It showed little or no signs of memory. At the end of three years its habits underwent no change.

In birds the cerebrum does not exceed the size of the cerebellum in the same degree as in quadrupeds.

In fishes, the cerebrum, properly speaking, is entirely wanting.

In proof of the use I have assigned to the cerebrum being correct, the memory of man is of a higher order, in capacity, extent, and variety, than of any of the animal creation.

That of quadrupeds inferior in many degrees, as is proved by the trouble that was found in teaching the learned pig.

The goose, although taught the same lessons as the pig, could not retain them.

In fishes there is reason to believe the memory inferior to that of birds.

As few opportunities occur of examining the brains of fishes of a very large size, I took advantage of that afforded me of making as particular an investigation of the brain of the squalus maximus, as I was able; and had two drawings made of the parts, and another of the brain of a squalus

acanthias, to bring to view some parts not seen in the other, as well as to show the proportions in size between this organ in a fish of 30 and one of 3 feet long of the same genus.*

The most remarkable difference between the human brain and that of the squalus is, that the cerebrum appears in the last entirely wanting, unless the enlargement from which the optic nerves go off may be considered as a portion of the cerebrum. These enlargements are separated from the other parts of the brain by the optic nerves going off in a transverse line between them, and the tubercula quadrigemina. Unfortunately, the brain was in degree mutilated; not only the enlargement from which the olfactory nerves go off had been destroyed, but also a portion of each of the anterior tubercula quadrigemina. The cerebellum, which was entire, is of the natural size.

The brain does not occupy more than one-third of the cavity of the cranium. The medulla spinalis is large in proportion to the brain. From the termination of what forms an appearance resembling the calamus scriptorius in the human brain, a fissure extends along the upper surface of the medulla spinalis, dividing it into two portions. On the opposite surface there is a similar fissure, into both of these a thin fold of pia mater extends; this adheres firmly to the surfaces with which it lies in contact.

The dura mater is dense, and adheres firmly to the cranium and theca vertibralis. The pia mater nearly resembles that of the human brain; it becomes thicker where it covers the spinal marrow.

* Plate XIII. XIV. XV.

It is deserving of remark, that the cerebellum in the squalus maximus is larger in proportion to the tubercula quadrigemina, than in the acanthias. These protuberances, from which the olfactory nerves arise, probably bore the same proportion as the tubercula quadrigemina, at least in the brain of a shark, preserved in the collection of the College, intermediate in its size; between the squalus maximus and acanthias that is the case.

On the Irritability of Nerves.

The nerves, before the year 1800, the time these observations were first published, had been considered as chords, having no powers of action within themselves, only serving as a medium, by means of which the influence of the brain might be communicated to the muscles, and the impressions made upon different parts of the body conveyed to the brain.

The difficulties which attend every attempt to investigate the real state of the nerves in the living body, and the almost impossibility of acquiring any information upon this subject after death, may be urged in excuse for this opinion having been so universally received, since it will be found, from the following experiments and observations. to be void of foundation.

With a view to ascertain whether nerves in a healthy state have any action within themselves, different experiments were instituted. The object of these was, to determine whether any contraction takes place in nerves, when divided in a living body; the extent of contraction, if any such occurred; and the circumstances by which it may be influenced.

For this purpose, the phrenic nerve in the horse was selected, as being more favourable, in many respects, than most others in the body, both from its superficial situation in the chest, and its great extent, without giving off any branches.

In making experiments of this nature, it is an advantage that the animal should be of a large size; and the regulations under which horses are killed in London, affords an opportunity of experiments being made on that animal, without giving the operator the painful sensations of having made any addition to the animal's sufferings.

As horses are killed at stated times only, and these occur in a part of the day which is necessarily occupied by my professional engagements, the following experiments were made by Mr. Clift, the conservator of the Hunterian museum, whose accuracy may be relied upon, as well as his abilities in conducting them, having been early initiated and long experienced in enquiries of this nature.

Experiment 1. Immediately upon a horse having been knocked down, the thorax was laid open, and the phrenic nerve of the right side, passing round the pericardium, exposed. It was nearly of the size of a crow quill, and slightly connected with the pericardium. In this state the point of one blade of a pair of scissors was passed under the nerve; and, by closing them, the nerve was transversely divided, without the smallest disturbance to its lateral connections. The two cut ends immediately retracted from each other, leaving the space of one inch between their extremities.

This experiment was repeated on a second horse, and the retraction of the cut ends of the nerve was found to be exactly one inch. It was repeated upon a third horse, and the retraction was found to be nearly two inches. In measuring the space between the two ends of the nerve, the compasses accidentally touched the lower portion, and the diaphragm was immediately thrown into action.

The result of this experiment proved in the most satisfactory manner, that any action the nerves are capable of exciting is nearly as strong after apparent death has taken place from a violence committed on the brain, as while the animal is in perfect health.

Monsieur Portal, in a paper on a new mode of performing the operation of amputation, published in the memoirs of the Academy of Sciences, for the year 1773, mentions an experiment made on the sciatic nerve of a dog, in proof of nerves not having a power of retraction, at least none deserving of notice.*

This experiment was repeated by Mr. Clift, on the sciatic nerve of the rabbit.

Immediately on dividing the nerve, the cut ends receded from one another: but that the result might be exactly ascertained, the rabbit was killed half an hour after the experiment was made, the parts were carefully dissected, and the space between the two cut ends measured; which was exactly six tenths of an inch.

* Memoire sur une nouvelle methode de pratiquer l'amputation des extrémités, par Monsieur Portal. Histoire de l'Academie des Sciences, 1773, page 542.

To ascertain whether this retraction was the consequence of a change taking place in the nerve itself, or arose from any other cause, the following experiment was made.

Exp. 2. As soon as a horse was knocked down, the chest was laid open, and the phrenic nerve of the right side exposed: twelve inches in length were immediately measured by a pair of compasses; and the limits of this portion were marked by a small pin, passed transversely through the substance of the nerve. The part included between the two pins was then separated from the rest of the nerve in the following manner.

The person who was to divide the nerve had a pair of scissors in each hand: and, having passed the point of one of the blades under the nerve, above the upper pin, and having done the same with a blade of the other pair of scissors below the lower pin, the two pair of scissors were shut at the same moment, and the nerve at these two parts cut through.

This portion was again measured, and, instead of being twelve inches, was now only eleven and one-eighth; so that the irritation produced by dividing it, had made it contract seven-eighths of an inch.

This experiment was repeated upon several horses; and in all of these repetitions there was a contraction produced; this varied in the different experiments, and in some of them was only three-eighths of an inch. When the nerve was divided very early after the animal had been knocked down, it was the greatest, and in proportion to the delay that took place, so was the diminution in the degree of the contraction.

In these experiments, the nerve as well as the surrounding parts was disturbed as little as possible, that the results might be the more readily and more accurately ascertained. This, however, makes them liable to an objection, which is, that the contraction might be produced by the cellular membrane surrounding the nerve; an objection which certainly can have little weight in the peculiar situation of the phrenic nerve, as it lies between the pleura and pericardium, where the cellular membrane can have little influence over it, while the pericardium is left entire.

As, however, the opinion of the cellular membrane being the agent by which the retraction of divided nerves is produced, has been very generally received, it was highly proper to attend to that circumstance, and have the experiment made in such a way as to prevent any surrounding part from acting upon the nerve; with this view the following experiment was made.

Exp. 3. The pleura was removed from twelve inches of the phrenic nerve of a horse, and afterwards the attachments between the nerve and pericardium were completely divided; under these circumstances, this portion of nerve was separated, as in the last experiment. This portion was again measured three hours after in its detached state, it was found to have lost six-eighths of an inch in length. The horse was twenty years old, and was killed on account of its age, which rendered it by no means a favourable subject for such an experiment.

With a view to determine whether the power of contraction in a nerve continued for any length of time after apparent death had taken place, and also to ascertain what proportion

of elasticity a nerve possesses, (for every part of an animal body that is not rigid, appears to be endowed with it in a greater or less degree) the following experiment was made.

Exp. 4. Eighteen inches in length of the phrenic nerve were measured, and separated by means of scissors; the contraction produced was only three-eighths of an inch; the experiment being made nearly an hour after the horse was knocked down. Upon being stretched with force, it elongated to eighteen and a half inches; and on being left to itself, retracted to seventeen and seven-eighths. It was kept till next day, and was again measured, when it was only seventeen and five-eighths: upon being stretched, it was elongated to eighteen and a half; but immediately on being left to itself, it was retracted to eighteen inches.

This experiment was repeated upon another horse, and the result was similar, both with respect to the contraction which took place after the nerve had been removed from the body, and the elongation which depended upon elasticity.

To ascertain if there was any difference in the appearance of a nerve when contracted, from one in a relaxed state, the following comparison was made.

Exp. 5. A portion of the phrenic nerve, about eight inches long, was removed immediately after the horse had been knocked down.

This was allowed to contract, and after it had remained quiet for twenty-four hours, its external surface was exposed by dissection, so that the appearance of its fibres could be distinctly seen. A portion of the same length was removed

from another horse, who died a natural death, and these were compared together.

The difference in the appearance of these two portions was very great; in the contracted nerve the fibres were all serpentine; in the other they were straight.

The serpentine transverse lines described by Monro, appear to be an effect of this contraction of the nerve; as they disappear when the nerve is fully relaxed or elongated. When the nerve is fully relaxed, these serpentine transverse lines are best seen; when the nerve is moderately stretched, they are much less evident; when the nerve is greatly stretched, beyond what it is ever in a healthy living animal, it appears uniform in its colour and consistency. Hence these lines are in the first place, to be considered as folds or joints in the nerve, and may be compared to the lines in the palm of the hand, serving to accommodate the nerve to the different states of flexion and extension.*

By soaking in water this appearance is lost.†

These serpentine lines in the phrenic nerve of a man who died of a locked jaw, when examined twenty-four hours after death, were much more distinct and regular than in the phrenic nerve of a man who died of a mortification of his arm.

These experiments upon so large an animal as the horse, made by a person well qualified for the purpose, and repeated sufficiently often to preclude any material fallacy, admit of the following conclusions being drawn from them.

1. That the nerves of an animal in health are capable of retracting themselves, when divided; and that this effect is

* Vide Plate XVI.

† Vide Monro on the Nervous System, p. 39.

entirely independent of the parts by which they are surrounded.

2. That this contraction takes place in the nervous fibres themselves, and is independent of the brain from which they originate, and of the muscles and other parts in which they terminate.

3. That the contracted nerve exhibits to the eye an appearance of contraction in its fibres, not to be seen when it is in a relaxed state.

As the nerves are so readily influenced by electricity, in exciting the muscles to action, it naturally suggested itself that some further information might be obtained in the present investigation, by means of experiments made upon the nerves by the electric fluid.

With this view the following experiments were instituted; and Mr. Carpue very obligingly assisted Mr. Clift, in making them, and carried one of Mr. Cuthbertson's large plate-glass electrical machines to the slaughter-house for that purpose.

Exp. 6. A portion of the phrenic nerve, twelve inches long, was exposed and divided at both ends, as in the former experiments.

When it had contracted to eleven inches and one-eighth, a strong electric shock was passed along its substance from one end to the other; but, when measured again, the length was exactly the same.

The portion of nerve was then dissected out and laid upon a piece of glass, in its detached state; it measured eleven inches and five-eighths. Several strong electric shocks were passed through it, in the direction of its fibres; but they did not produce the smallest effect upon it.

This experiment was repeated upon another horse, and the result was the same.

Exp. 7. Half an hour after a horse had been knocked down, twenty-four inches in length of the nerve called par vagum were laid bare, and a portion of it detached from its lateral connections, so that a piece of glass twelve inches long, was admitted under it without dividing the nerve from the trunk. In this state electric sparks were drawn from it, and several strong electric shocks passed through it; but there was not the smallest change to be perceived either in its length or appearance.

From these experiments it appeared that when the nerve had contracted itself in consequence of being divided, no increase of that contraction was produced by the electric fluid.

To ascertain whether electricity, was capable of exciting contraction in a nerve that had not been previously irritated, the following experiment was made.

Exp. 8. Twelve inches of the phrenic nerve were measured, and the limits of that portion marked by pins stuck through the nerve. This portion of nerve in its relaxed undisturbed state, had electric shocks passed along its substance: but these were found upon measuring the portion of nerve to have produced no diminution of its length.

When this portion was separated, as in the former experiments, it contracted to eleven inches and three-eighths: a diminution of five-eighths of an inch.

The electric fluid in this last experiment excited the action of the diaphragm, but produced no evident or

permanent contraction of the nerve; and when the nature of the contraction of a nerve is considered, it is not to be expected that permanent contraction can be ascertained in any other way than by separating entirely a portion of nerve from the rest of the system. For the action is continued in tremors along the nerve in quick succession, and when the muscle has been excited to contract, the complete action of the nerve is finished, and it immediately relaxes, or returns to that state which admits of a new action.

This appeared to be the case in several experiments made upon the nerves of frogs, and of quadrupeds of a higher order, by two different metals, as described by Galvani. In all of them there was a convulsion of the muscle, and a tremor in the nerve: but such was the rapidity of the effect, that it could not be decided that any motion took place in the nerve, except what arose from the agitation produced by the action of the muscle.

The experiments and observations which have been stated, prove the nerves not to be entirely passive.

On the Influence of the Nerves upon the Action of their corresponding Arteries.

That the pulsation of the arteries correspond in frequency with the left ventricle of the heart, is universally admitted, but those pulsations continuing in the arteries after the limb to which they belong is rendered paralytic, has led to the belief that all arterial action is independent of nervous influence. The object of the present observations is to show that the nerves which accompany the arteries regulate their actions, and it is through their agency that the blood

is distributed in different proportions to the different parts of the body.

The facts which have led me to conclude that this office is performed by the nerves, I shall lay before my audience in the order in which they occurred.

An officer had been wounded by a musket ball in the leg; a seton was passed in the course it had taken, and brought through the skin just beyond the part in which it was lodged; a caustic was then applied to the skin, just below the tuberosity of the tibia to which the ligament of the patella is attached; it produced great pain all round the joint and through the leg, and, what was very remarkable, the matter in the canal surrounding the seton rose and fell through a space of some extent. This circumstance induced me to feel the pulse at the wrist, and to keep my finger upon it the whole of the time this effect upon the pus continued, which was for several minutes, but the pulse at the wrist had been in no degree disturbed. The increased force of the action of the arteries, rendered evident by the effect upon the pus, following so closely upon an irritation on the neighbouring nerves, made it clear that it arose from that cause, and brought to my recollection an instance in which the aorta had been seen pulsating with great violence, in consequence of an irritation upon the nerves of the urinary bladder. To ascertain whether such a connection between the actions of nerves and arteries could be demonstrated in a state of health, as well as disease, I instituted the following experiments, which were made in the presence of the late Mr. Gatcombe and other gentlemen competent to form a judgment respecting them.

The carotid artery of a dog was laid bare, the par vagum and intercostal nerve, which in that animal form one bundle, were separated from it by a flattened probe for one-tenth of an inch in length; the head and neck of the dog were then placed in an easy position, and the pulsations of the carotid artery attended to by all present, for two minutes, that the eye might be accustomed to their force in a natural state; the nerve passing over the probe was then slightly touched with the kali purum.

In a minute and a half the pulsations of the exposed artery became more distinct; in two minutes the beats were stronger, and in three more violent; in four minutes the violence was lessened, and in five minutes the action was restored to its natural state.

This experiment was repeated, with the same results, upon a rabbit; and in that animal the par vagum was separated from the intercostal nerve, which cannot be readily done in the dog: and it was found when the par vagum alone was irritated, no increase took place in the force of the action of the artery. The carotid artery was chosen as the only artery in the body of sufficient size that can be readily exposed, to which the nervous branches supplying it can be traced from their trunk. This experiment was repeated three different times, so as to leave no doubts respecting the result.

Having ascertained by these experiments, that the increase and diminution of contraction of an artery does not depend upon irritability of the artery itself, but nervous influence, I made the following experiments to determine whether heat or cold had the greatest effect in stimulating the nerves

to produce this effect upon the artery. The wrist of one arm was surrounded by bladders filled with ice; and after it had remained in that state five minutes, the pulse of the two wrists was felt at the same time, and the beats in that which had been cooled were found evidently the strongest. A similar experiment was then made with water heated to 120° or 130°, beyond which the heat could not be submitted to, and the pulse was found to be softest and weakest in the heated arm; when one wrist was cooled and the other heated, the stroke of the pulse in the cooled arm had great force beyond that in the heated one.

These experiments were repeated upon the wrists of several young men of different ages, and on those of several young women, with an uniform result; which explains the glow produced by the cold bath, and the other beneficial effects of cold bathing, in a more satisfactory manner than has been hitherto done.

This influence of the nerves upon the arteries throws considerable light upon some of the most important actions in the animal economy. By its means, the same arteries, at different times, allow very different proportions of blood to pass through them, and those employed in furnishing blood for the secretions have the supplies regulated; which explains the use of the system of nerves with which the blood vessels of the viscera are so abundantly furnished.

The erection of the penis produced by a particular state of mind, is one of the effects of this influence of the nerves upon the arteries; and the stoppage of the secretions from the same cause is another of an opposite kind.

The ready supply of blood to a limb by the small anastomosing branches, when the principal arterial trunk is obliterated, depends upon the same cause.

That the growth of the nerves keeps pace with that of the other parts of the body is generally believed; although it is admitted that in the child the nerves, as well as the brain, are larger in proportion than the bones and muscles.

In what ratio the trunks of the nerves increase, just before they send off crow-foot expansions, has not, I believe, been attended to in the enlargement of any organ; at least Dr. William Hunter makes that remark respecting the gravid uterus. Upon examination, I find that the spermatic nerve in the uterus, six months after pregnancy, is about one-fourth larger than in the unimpregnated state.

That the presence of nerves, and that in no inconsiderable number, is absolutely necessary for the growth of parts, is beautifully illustrated in the horns of the deer. When the horns are examined in their half-grown state, the velvet is massy and thick, the buds of the horn soft and tender; so that the part which is to form the tips can be eaten, although a little gritty in the mouth. At this stage of growth every one knows how hot these parts are to the feel of the hand, and how the animal shrinks when any thing comes against them. If the head, after death, is injected, the arteries are found to run generally parallel to each other; and it is this course which gives the fluted appearance to the surface of the horn.

The nerves that accompany the arteries are rather softer in texture than in other parts of the body: they are not readily traced, as their direction is the same as that of the bony

fibres; and as the horn grows thicker, both the arteries and nerves become incased in bony canals, so that it is only those which lie between the velvet and the horn that can be examined with any degree of accuracy. My principal object in this investigation was to ascertain, as nearly as it could be done, the proportion of newly-formed nerve to the newly-formed arteries, and Mr. Bauer considers it the greater of the two. This shows that the growth of the horn depends upon the nerves; for otherwise what purpose is the nerves to answer? The sensibility of the horn is a disadvantage to the animal; and as soon as the horn has attained its full growth, both the nerves and arteries are obliterated. The mode in which a sudden and complete stop is put to the growth of the horn, as well as to its sensibility, is so beautiful that, although it does not immediately belong to this subject, I cannot help taking notice of it. — When the horn has arrived at its destined size, the projecting ridge at its base, in which there are holes for the arteries, veins, and nerves, becomes solid, and presses upon these parts so as to obliterate them.

From all that has been stated, the formation of parts of animal bodies, their regeneration, and their increase, depend upon natural or diseased excitement of the nerves, whether these excitements are produced by the mind, the passions, or the effect of the impregnation of the ova upon the nervous system; the changes in the blood vessels being secondary, and their actions under the guidance of the influence of the nerves.

The deer's horns, which have so short a duration, and answer so temporary a purpose, being so largely supplied with nerves, appears to me conclusive upon this subject.

Hints on Animal Secretions.

The brilliant discoveries of Sir Humphry Davy on the powers of electricity in producing chemical changes, suggested to me the idea, that the animal secretions may be produced by the same means.

To prosecute this enquiry with every advantage, requires a knowledge of anatomy, physiology, and chemistry, rarely to be met with in the same person. I have, therefore, availed myself of the assistance of the different members of a society, the object of which is the improvement of animal chemistry, their intimate acquaintance with these branches of science rendering them peculiarly fitted for such an undertaking.

It is one of the most importaut subjects to which Sir Humphry Davy's discoveries can be applied, and he has given it the consideration it deserves.

The voltaic battery is met with in the torpedo and electrical eel; and although it is given only as a means of catching their prey, and defending themselves, and therefore not immediately applicable to the present enquiry, yet it furnishes two important facts, — one, that a voltaic battery can be formed in a living animal; the other, that nerves are essentially necessary for its management: for in these fishes, the nerves connected with the electrical organs exceed those that go to all the other parts of the fish, in the proportion of 20 to 1. The nerves are made up of an infinite number of small fibres; a structure so different from that of the electric organ, that they are evidently not fitted to form a voltaic battery of high power, but their structure appears

to Sir H. Davy to adapt them to receive and preserve a small electrical power.

That the nerves, arranged with muscles so as to form a voltaic battery, have a power of accumulating and communicating electricity, is proved by the well-known experiment of taking the two hind legs of a vivaceous frog; immediately after they are cut off, laying bare the crural nerves, applying one of these to the exposed muscles of the other limb, and then, when the circle is completed by raising the other crural nerve with a glass rod, and touching the muscle of the limb to which it does not belong, the muscles of both are excited to contractions. There are several circumstances in the structure of the nerves, and their arrangements in animal bodies, which do not appear at all applicable to the purpose of common sensation, and whose uses have not even been devised. Among these are the plexuses in the branches of the par vagum which go to the lungs, and in the nerves which go to the limbs; and the ganglions, which connect the nerves belonging to the viscera with those that supply the voluntary muscles, and the course of the nerves of the viscera, which keep up a connexion among themselves in so many different ways. The organs of secretion are principally made up of arteries and veins; but there is nothing in the different modes in which these vessels ramify, that can in any way account for the changes in the blood out of which the secretions arise. These organs are also abundantly supplied with nerves. With a view to determine how far any changes could be produced in the blood by electricity at all similar to secretion, Professor Brande, who had began his career in animal chemistry with so much success,

made the following experiments, in the suggestion of which Sir H. Davy afforded him every assistance.

Experiment 1. *made in the middle of Jan.* 1809.—The conductors from twenty-four four-inch double plates of copper and zinc, charged with a very weak solution of muriatic acid, were immersed in four ounces of blood, immediately on its having been drawn from a vein in the arm. The temperature of the blood was kept up at 100° during the experiment. The apparatus was so constructed, as to admit of the products at the negative and positive wires being separately collected and examined. When the electrisation had been carried on for a quarter of an hour, all action seemed to have ceased.

The blood which had surrounded the negative wire, was of a deep red colour and extremely alkaline: that surrounding the positive wire was slightly acid, and of a brighter hue.

In this experiment, the coagulation of the blood was not materially affected by the electrical power alluded to.

Exp. 2. *made* 18*th of Jan.* 1809.—Finding it necessary to submit perfectly fluid blood to the action of electricity, the following experiment was undertaken, with a view of keeping it the longest possible time in that state.

A deer having been pithed, the abdomen was immediately opened into, and a length of about four inches of a large vein in the meso colon was detached from the neighbouring parts. Two small platina wires, connected in the usual way with forty three-inch double plates, were inserted into this detached portion of vein, and secured by ligatures, having their points at a distance of about one inch from each other.

The communication with the battery was kept up for one quarter of an hour; a third ligature was then tied in the centre of the detached vein, in order to cut off the connexion between the positive and negative ends. On removing the portion of the vein included by the ligatures, and containing the conductors, it was found that the gaseous products had forced out nearly the whole of the blood at the part through which the wires were inserted: alkaline and acid matter were readily detected, but no new product could be discovered.

Finding the coagulation of the blood an insurmountable obstacle to the long-continued electrical action, the serum only was employed in the following experiments.

Exp. 3. *made* 10*th of March* 1809.—The conductors from one hundred and twenty four-inch double plates, highly charged, were brought within two inches of each other, in some recent serum of blood, obtained free from the colouring matter, by carefully pouring it off from the coagulum. Coagulated albumen was rapidly separated at the negative pole, and alkaline matter evolved; at the positive pole, a small quantity of albumen was gradually deposited, and litmus paper indicated the presence of acid. These are the effects produced by a high electrical power upon serum.

Exp. 4. *made* 14*th of April* 1809. — Was undertaken to ascertain the effect of a low power. A battery was employed consisting of twelve four-inch double plates of copper and iron. In this case there was at first no appearance of coagulation at either pole; in five minutes the positive wire became covered with a film of albumen; and in fifteen minutes a filament of about a quarter of an inch in length

was seen floating in the fluid, and adhering to the same wire.

Exp. 5. made 6th of May, 1809. Two small platina cups, connected by a large quantity of cotton well washed, and each containing one ounce of serum, were rendered positive and negative by thirty double three-inch plates very weakly charged. The process was continued during twenty-four hours. This power had not been sufficient to produce coagulation at the negative pole. On examining the fluid in the negative cup, it was found to consist principally of an alkaline solution of albumen. The fluid in the positive cup was rather turbid, it reddened litmus, and was slightly acid to the taste.

On standing it deposited a few flakes of albumen. When evaporated, it afforded saline matter with excess of acid.

By these experiments it is ascertained, that a low negative power of electricity separates from the serum of the blood an alkaline solution of albumen; that a low positive power separates albumen with acid, and the salts of the blood.

That with one degree of power, albumen is separated in a solid form; with a less degree it is separated in a fluid form.

From these facts the following queries are proposed.

1. That such decomposition of the blood by electricity may be as near an approach to secretion, as could be expected to be produced by the artificial means at present in our power.

2. That a weaker power of electricity than any that can be readily kept up by art, may be capable of separating from the blood the different parts of which it is composed, and forming new combinations of the parts so separated.

3. That the structure of the nerves may fit them to have a low electrical power, which can be employed for that purpose, and as such low powers are not influenced by imperfect conductors as animal fluids, the nerves will not be robbed of their electricity by the surrounding parts.

4. That the discovery of an electrical power, which can separate albumen from the blood in a fluid state, and another that separates it in a solid state, may explain the mode in which different animal solids and fluids may be produced; since, according to Mr. Hatchett's experiments, albumen is the principal material of which animal bodies are composed.

5. That the nerves of the torpedo may not only keep the electric organ under the command of the will, but charge the battery by secreting the fluid between the plates that is necessary for its activity.

6. As albumen becomes visibly coagulated by the effect produced from twelve four-inch double plates of copper and iron, a power much too low to affect even the most delicate electrometer, may not this be occasionally employed with advantage as a chemical test of electricity, whilst the production of acid and alkali, affected by still inferior degrees of electricity to those required for the coagulation of albumen, may likewise be regarded as auxiliary tests on such occasions?

If these facts and observations appear to throw any light upon the principle of secretion, it may be an advantage to medical science, that they should be laid before the public, as hints for future enquiry.

This was first done on the 22d of June, 1809. Since Mr. Bauer's analysis of the blood, and his observations on the

structure of the brain and nerves have been explained to my audience, the transparent elastic mucus soluble in water, placed between the membranous plates in the organ of the torpedo and electrical eel, is probably all that is necessary to keep the organ constantly charged; and the arrangement of globules in this mucus in the structure of the nerves keeps them in a state of activity for performing their different functions.

Before I conclude these observations, in justice to myself, I shall mention that they were read, on the 22d of June, 1809, at the Royal Society, before Dr. Wollaston's remarks in the Philosophical Magazine were published.

I was led to the present investigation while preparing my Lectures on the Hunterian Collection, in which the secretions in different animals are to be considered. In September 1808, I engaged Professor Brande to assist me in prosecuting this enquiry. In November, I communicated my opinions to Sir Joseph Banks, and stated that I should bring them forward in my Lectures; at that time Dr. Young's Syllabus was not published, and Dr. Wollaston's opinions were unknown to me. Dr. Berzelius, Professor of Chemistry at Stockholm, published a work on Animal Chemistry, in the year 1806, in the Swedish language, in which he states, in several places, that he believes the secretions in animals to depend upon the nerves, although he is unable to explain how the effect is produced.

In proof of his opinion the following experiment is adduced.

"Trace all the nerves leading to any secretory organ in a living animal, and divide them, being careful not to injure

the blood-vessels and the structure of the organ itself, as little as may be; notwithstanding the continued circulation of the blood, the organ will as little secrete its usual fluid, as an eye, deprived of its nerve, can see, or a muscle, whose nerve has been divided, can move. We may therefore easily conceive that any trifling alteration in the nerves of the gland may materially affect its secretion, the supply of blood being in every way perfect."

He says, the agency of the nerves in secretion has generally been disregarded, because our attention is only called to their secret mode of acting, when we discover the insufficiency of all other explanation.

Dr. Berzelius's work was shown to me by Sir Humphrey Davy, while these observations were in the press.

LECTURE IV.

An Attempt to ascertain the Functions of the different parts of the Brain, by paying attention to the symptoms produced when they are injured.

PART I.

THE various attempts which have been made to procure accurate information respecting the functions that belong to individual portions of the human brain, having been attended with very little success, it occurred to me that were surgeons who are well skilled in anatomy to collect in one view all the facts they had ascertained upon this subject, a body of evidence might be formed that would materially advance this highly important investigation.

For this purpose I have brought together the following symptoms collected in the course of my professional pursuits, stating them as so many experiments made upon the brain, in which the conclusions tend to elucidate the functions of its several parts.

The materials for such an enquiry that can be furnished by an individual from his own experience, are necessarily very small; they may, however, be sufficient to show the advantages to be derived from this mode of investigation, and by that means connect still more closely the pursuits of anatomy with those of philosophy.

SECTION I.

Watery Tumours upon the Cranium.

When watery swellings are met with between the upper portion of the cranium and periosteum, they produce epileptic fits; these are removed by cutting down upon the skull. When these tumours have continued long, the skull under them becomes thickened, and a fluid forms under the bone; this produces blindness, deafness, depression of spirits; these are removed by perforating the skull and letting out the fluid.

SECTION II.

Thickening of the Membranes of the Brain.

When the dura mater over the cerebrum is thickened considerably, and the pia mater under it is in the same thickened state, it produces loss of memory, epileptic fits followed by death. The same symptoms are the effects of pressure upon the cerebrum from whatever cause.

SECTION III.

The effects of an undue proportion of Water within the Cranium.

Before I enter into the particular effects that take place when water is collected in the brain, it is necessary to mention that sudden pressure upon the cerebrum takes away all sensibility. This happens when it is made upon the external surface, through the medium of the dura mater, after the operation of the trepan, before the skull at that part is ossified; it happens, also when made through the medium of the ventricles, which can be done in cases of spina bifida, by pressing upon the watery tumour in the back, and forcing the water up into the ventricles: sensibility returns as soon as the undue pressure is removed.

Faintness is the consequence of the pressure, to which the cerebrum has been accustomed, being suddenly taken off. The removal of a coagulum of blood, half an inch thick, from between the skull and dura mater, made the pulse nearly stop, but as soon as the person recovered from this faint state, he was perfectly well. Pressure to a certain degree uniformly kept up, appears to be necessary for the performance of the healthy functions of the cerebrum, and any increase or diminution of this pressure puts a stop to them. It is asserted, that in addition to this pressure the pulsatory motion of the blood in the arteries of the cerebrum is also necessary; but the late John Hunter, whose accuracy in a point of this kind is not to be doubted,

retained his senses, although the heart had apparently ceased to act.

Although insensibility is the common effect of undue pressure upon the cerebrum, it will not be found to be a necessary consequence of unusual pressure upon the cerebellum.

The facts which have been stated, point out the use of the water in the ventricles of the brain; and account for the great variety which is met with in the form and extent of the posterior cornua of the lateral ventricles, their dimensions varying according to the quantity of water which is necessary to keep up the pressure required.

The size of the ventricles appears to be very immaterial, since, even when they are increased so as to contain above six ale pints, the functions of the brain can be carried on, and the growth of the body proceeds; but after the skull is completely ossified, an increase of two or three ounces by its pressure produces insensibility.

That the ventricles should admit of being enlarged to so great an extent, without any of the senses or faculties of the brain being destroyed, is in itself a curious fact, and of so much importance, with respect to the physiology of the brain, that I shall detail two cases, which illustrate one another. In the one, the accumulation of water proceeded, as it will appear, as far as it could go, without materially impairing the organ; it then stopped, and the boy grew up, with all his faculties, although much weakened. In the other, the water continued to increase, and the faculties of the brain were destroyed.

A boy, at a month old, had so rapid an increase of the size of his head, as to evince an accumulation of water in the brain; in the first five years it had become of the size I saw it. The parents, at least, judging from recollection, believe that it never after increased. At this age, when his head was exposed to the sun's rays, their passage through it was seen as through a horn lanthorn, so transparent is the medullary substance of the brain when it is not formed into a large mass. He at that time caught the natural small-pox, which nearly proved fatal: but after his recovery the head showed no disposition to increase in size, the child in all respects improved, and for the first time began to walk. When he was fourteen, the skull had completely ossified. At nineteen, the time I first saw him, he was five feet six inches high; his head measured in circumference thirty-three and a half inches. He had grown in the course of the last year about two inches, which is more than he usually had done in any one year.

All the organs of sense performed their office; savoury food was agreeable to his taste, but he was moderate in eating.

His sight was good, but looking with attention at objects more than half an hour at a time, appeared to strain his eyes.

His head was so heavy, that the muscles of the neck were unable to support it for many hours together; when in the act of lying down, the head required being supported by another person.

He slept with more ease on the right side, and the left side of the head appeared to the eye to be rather the largest. In lying down he felt what he described to be a momentary thrilling heat, on the upper part of the brain, in the line of

the longitudinal sinus. Lying upon his back strained his eyes so much, that he could not remain in that posture; stooping forwards became oppressive to his eyes. The least weight in his hand, as a tea cup, made it tremble; all sudden noises jarred his head, and produced giddiness. When he fell down, the jar rendered him insensible; at one time this was the case for fifteen minutes, without leaving any permanent indisposition.

His head ached when exposed to heat. He had no illness after the small-pox.

His sleep was easily broken; he never dreamed; he was fond of reading and writing; had a taste for poetry, and repeated verses out of Cowper. His memory of common things was very good. He never expressed any attachment or passion for women. He was of a mild disposition, but when irritated his whole frame was in a state of agitation, which, however, soon went off.

The brain performed all its functions, but not with vigour, nor for any length of time.

I saw him again at St. Thomas's Hospital, May 4, 1822. He was then twenty-seven years old, and did not remember me. His height and the circumference of the skull remained exactly the same; the organs of sense were unimpaired; his head could not bear any weight. The muscles of the neck could support the head all day. He now had been able to lie with most ease for years on the left side. The two sides of his head appeared to be the same; the thrill on lying down was now under the left parietal bone; lying on the back, stretched his eyes; they had become stronger; his memory was much impaired; could not repeat verses, only

part of the Lord's Prayer, which he said every night; fond of liquor, said, it put him in spirits, and he liked to treat his friends; it went off rapidly by urine; loved to kiss a girl under the misletoe; penis full grown, one testicle very small; had erections and dreams of women, but no emission; cheerful and mild; had tantrums, which lasted half an hour; the only fits he had since being in the Hospital were on the first of May, in which he was insensible ten minutes, one in the morning, one at noon, and one at night.

In another boy, an enlargement of the head was perceived at three months old, which increased for three years; it then appeared stationary, and the child was sensible. The upper part of the skull at that time began to ossify, and in three years more the ossification was so far advanced, that there was only an irregular space at the fontinelle, and a small space between the two portions of the os frontis. The child, who had continued sensible for three years, became gradually less so; did not know what he did; heard sounds, but could not see. At six died. Upon examination after death, the child was three feet three inches high, the skull twenty-seven inches round; the water contained in the two lateral and third ventricles was six ale pints and a half in quantity. The cerebrum formed a thin layer of medullary substance on the inside of this cavity. The cerebellum was intire. The lining of the lateral ventricles was tough, the septum lucidum was elongated, so that the corpus callosum was raised up close to the dura mater, the falx being nearly obliterated.

The water in the third ventricle had split the fornix and septum lucidum into two, and the thin membranes of the

septum had holes in them, making a communication between the third and lateral ventricles.

The substance of the brain surrounding those cavities, as well as the pia mater covering it, had no convolutions; there was one continued smooth surface. On the right side, upon which the child was usually laid, there were no remains of medullary or cortical substance, and there the pia mater and dura mater adhered together. There was no remaining brain between the third ventricle and sella turcica. On the left side of the left hemisphere the medullary and cortical substance were only half an inch thick. The corpora striata and thalami nervorum opticorum were small and tough: the union between the thalami was elongated into a broad flat ligament.

The two commissures and iter ad infundibulum had the natural appearance.

The pituitary gland had become flattened.

The fourth ventricle, tuberculum annulare and cerebellum, had nearly the natural appearance. The olfactory nerves were tough and small, the optic nerves had no medullary pulp, which explains his being unable to see; the other nerves going out of the skull had undergone no change. The weight of the whole brain was *2 lb. 3 oz.* 1*dr.* The weight of the whole brain of a child between six and seven years, *2 lb.* 12 *oz.*

The preceding facts show, that the cerebrum is made up of thin convolutions of medullary and cortical substance, surrounding the lateral ventricles; these are unfolded when the cavities of those ventricles are enlarged, and in this unfolded state, from the present observations, we find the functions belonging to this part of the organ can be carried on.

Although the quantity of water may be so much increased without material injury to the functions of the brain when the skull is not ossified, after complete ossification has taken place, even a few ounces of water in the lateral ventricles have been known to produce so much unusual pressure as to bring on head-ache, general uneasiness, a sensation as if the head were too large, loss of spirits, convulsions, loss of memory of recent events, idiotism, insensibility, anddeath.

One ounce and a half of water in the lateral ventricles, at four and a half years old, were accompanied by pain in the head, and great general irritability.

Five ounces, at seven years, by insensibility, for fourteen days before death.

Two ounces and one half, at nine years, by violent head-aches, stupor, and unwillingness to be moved.

Three ounces, at eleven years, were attended with loss of recollection of recent events. This began at the age of ten. A stupor of twelve days preceded death.

Four ounces, at eleven years, were followed by the sensation of the head being too big, loss of speech, insensibility, convulsions.

Eight ounces, at seventy-four years, were accompanied by a state of idiotism for ten days, and then death. In one instance this was the case.

Five ounces of water, in two small cells in the anterior, and two in the posterior cornua of the lateral ventricles, at six years of age, were the only evident cause of pain in the lower parts of the belly, occasional constipation, and violent pain in the bowels.

When accumulated in the third ventricle, without any increase in the lateral ones, distressing pain in the head, loss

of speech, and insensibility have been met with. In one case two ounces produced this effect.

Two drams of water, in the third ventricle of an aged dog, were attended for four years by fits of insensibility, pain in the head — only relieved by opium: convulsions, and death. These fits of insensibility were probably brought on by any unusual exertion that agitated the contents of the skull, and went off when the head had been some time in a state of rest.

Two ounces of water in the lateral ventricles, one ounce and a half under the tuberculum annulare, between the tunica arachnoides and pia mater, at five years of age, were followed by painful sensations in the stomach, lower belly, bowels, and across the legs.

Two ounces of water in the ventricles, one under the tuberculum annulare, at three years, appeared to produce not only painful sensations in the lower belly, stomach, and bowels, but pain in the head, and pain across the legs, as if they were cut with an instrument.

When not only in the ventricles but between the tunica arachnoides and pia mater over the hemispheres, and also upon the tubercula quadrigemina, the apparent consequences in one case were depression of spirits, pain in the back of the head, and mania.

Water in the third ventricle, in sufficient quantity to separate and keep apart the thalami nervorum opticorum, also between the tunica arachnoides and pia mater, over the hemispheres, and under the tubercula quadrigemina, in an adult were attended by pain in the back of the head, low spirits, and after drinking wine very high spirits. This ended in mania, and after three months in death.

Two ounces of water in the lateral ventricles, one between the dura and pia mater, the space between the tunica arachnoides and pia mater loaded with it, in an adult were attended by melancholy, imbecility, apoplexy, and paralysis. The paralysis took place after the last apoplectic fit, and death ensued.

Two ounces in the lateral ventricles, and a very unusually vascular state of the dura mater in an adult, were followed by violent affections of the præcordia in sleep, which led to suicide.

When between the dura and pia mater, in considerable quantities, a state of melancholy and imbecility of mind was met with in the following instance.

A gentleman fell from a horse: from that time he had constant head-aches, gradually became melancholy and imbecile. He lived three years in that state. Four ounces of water were found between the dura and pia mater, on the right side. There was an exostosis one-eighth of an inch long on the parietal bone, with a sharp point, in contact with that part of the dura mater under which the water lay. There were four ounces in the lateral ventricles; the posterior cornua were very small; there were also three ounces on the basis of the skull. The effusion was, probably, very gradual.

SECTION IV.

The effects produced by Concussion of the Brain.

Concussion of the Brain produces delirium and coma: these symptoms go off; they sometimes in a few days return and prove fatal. This happened in two cases, and no appearance of alteration of structure in the brain was met with after death.

In the torpid state, commonly attendant upon any violent shake being given to the brain, the senses are so much impaired that little information can be gained respecting the effects produced upon the internal organs. The bowels have been found, under such circumstances, to be acted on by aperient medicines with great difficulty.

A gentleman fell from his horse, and had a concussion of the brain. While in that state it required sixty grains of jalap and twenty of calomel to procure one evacuation from the bowels.

Concussion of the brain, followed by tumefaction of the scalp, in one instance produced pain in the head, dizziness, ringing in the ears.

These were removed by dividing the tumefied scalp.

Concussion in one case produced insensibility for twelve hours, hæmorrhage, to the amount of sixteen ounces, from one ear, of which he became deaf. — It was more than a year before he sufficiently recovered his senses to enable him to return to the practice of the profession of Surgery.

This shows that the brain may recover from severe concussion if no alteration of structure has been produced.

SECTION V.

The Effects produced when the Blood-vessels of the Brain are preternaturally dilated or diseased.

Sudden dilatation of the blood-vessels of the cerebrum, in consequence of exposure, to the sun is sometimes accompanied by delirium, loss of speech, and the power of swallowing. In a case of coup-de-soleil in the West Indies, these symptoms were produced, and the person died in two hours.

The brain was examined four hours after death. The scalp felt hot, was loaded with blood, the cerebrum was hot to the feel, and a general distension of the blood-vessels of the pia mater was the only unusual appearance, except that the substance of the cerebrum was very soft.

A dilated state of the veins of the cerebrum has been attended with head aches which were very severe when the body was placed in an horizontal posture.

In the case of a young lady who had suffered severely from head aches, which were so violent at night when she lay without a pillow, as to produce occasional delirium: after death, the veins of the medullary and cortical substance of the cerebrum were found considerably enlarged.

When the smaller arteries of the cerebrum are preternaturally enlarged, while those of the cerebellum are not, delirium has taken place, followed by a fit resembling

apoplexy, and a paralytic affection on one side; the following is an instance of this.

A man sixty years of age, had, from anxiety, an apoplectic fit which lasted some hours, leaving a paralytic affection; in seven days, under a course of electricity, he recovered the use of the paralytic limbs. In four months, while under very great anxiety of mind, he became delirious, and one side became paralytic, in which state he died. There were no other appearances than those above mentioned.

An obstruction to the passage of the blood through the right internal carotid artery, was attended by a succession of apoplectic fits, unaccompanied by any paralytic affection. Viz. An officer had a succession of apoplectic fits at intervals of one, two, and three months, the first of six days continuance, the second a few hours, the third and fourth shorter; the last terminated in death. On examining the brain, the right internal carotid artery was filled with a solid coagulum of blood, which extended some way into the smaller branches.

When the smaller branches of the arteries of the pia mater are so much loaded with blood, as to give the appearance of extravasation, the consequences have been apoplexy, paralysis, and death.

An aneurismal enlargement of both the internal carotid arteries to the size of marbles projecting into the cavernous sinuses was the only apparent cause of attacks of mania with consciousness of being insane in the following case.

A lady who had unequal spirits, and occasionally double vision, had an attack of giddiness and mania; the eyes were red, the hands benumbed, and death ensued. On examining

the brain, the aneurisms were discovered, and the optic nerves were found wasted.

SECTION VI.

The Effects produced by extravasated Blood in the Brain.

Blood in the lateral and third ventricles, has been attended by repeated fits of vomiting and coma. A coagulum of blood, the size of a common leech, lying upon the plexus choroides in both lateral ventricles, and two ounces of serum, were found in a person who had the symptoms stated.

Half an ounce of blood in the fourth ventricle produced a fit which, in twenty-four hours, terminated in death.

Under the anterior lobes of the brain, three ounces of coagulum upon the bases of the skull produced hiccoughs and stupor.

Under the cerebellum, a coagulum produced convulsions of the neck and body, with drawing up of the feet, without stupor.

In the folds of the pia mater, covering one hemisphere, blood extravasated in small quantities, produced a paralytic affection of the opposite side without any other symptom.

Blood in the folds of the pia mater, over the posterior lobes of the brain and serum in the cornua of both the lateral ventricles, were attended by giddiness, paralysis, straight objects appearing crooked, loss of memory, and at last idiotism, as in the following case.

A person sixty-nine years old, had a paralytic stroke from which he recovered; but had giddiness, and straight lines appeared crooked. He had a second, which terminated

in idiotism which lasted a year and a half; he then died. It appeared that there had been two distinct extravasations of blood in the pia mater, which had communicated with the cornua of the lateral ventricles in which were deposited six ounces of serum.

A large cyst filled with water, after apoplexy, in consequence of the blood having been absorbed, just above the left ventricle, rendered the neighbouring brain laterally dense, but not the anterior part of the hemisphere: at the end of two years, the person committed suicide.

In the right thalamus nervi optici, extending into the lateral ventricles, an ounce of coagulum produced paralysis of the left side of the body, both eye-lids closed, the mouth was drawn on one side, no perception of light with the left eye; these effects were succeeded by coma.

Between the dura mater and skull, covering the right hemisphere, a coagulum half an inch thick, produced stupor which went off on its removal, but taking off the pressure produced faintness for a few minutes.

A layer of coagulable lymph, spread over the union of the optic nerves, the pineal gland, and tuberculum annulare, was followed by permanent contraction of the muscles between the occiput and vertebræ of the neck, dilatation of the pupils and a great degree of deafness.

Serum under the cerebellum, in the quantity of two ounces, brought on restlessness, convulsions, incessant talking, at times incoherent, and the eyes became insensible to light.

SECTION VII.

The Effects produced by Depression from Fracture and from thickening of different Portions of the Skull.

Unusual pressure of the skull upon the middle lobe of the brain, was attended with pain in the stomach, torpor of the bowels, nausea, retching, pain between the shoulders, and in the feet. The pressure was continued by a bony tumour, in the form of a hemisphere, half an inch in thickness, the broad surface attached to the parietal bone.

Unusual pressure on the upper part of the hemispheres, want of sleep, head-ach, and stupor.

Those effects went off upon removing a depressed portion of the under table of the left parietal bone close to the sagittal suture, not more than an inch in length, and depressed for about one-eighth of an inch.

Pressure on both of the anterior lobes of the brain, produced heaviness, loss of memory, and depression of spirits bordering on idiotism. The frontal bone was increased in thickness to a considerable degree. The person had been many years resident in India.

Pressure on the anterior lobes of the brain, with water between the tunica arachnoides and pia mater covering the superior part of the hemispheres, produced an apoplectic fit, heaviness, loss of memory, and a second apoplectic fit which terminated in death. The pressure was from a thickening of the os frontis, with small exostoses the size of peas, upon its inner surface. The anterior lobe cerebri had a flattened

appearance, and the tunica arachnoides was loaded with water.

On the lower and lateral part of the left posterior lobe of the brain brought on uneasiness in the skin of the left cheek, extending along the chin, throat, and trachea, hissing noise in the ears, inability to speak the words the person wished to articulate, using others in their place although conscious of doing so, and unable to correct it. Numbness in the arms and legs. These effects ceased on taking off such pressure, in the following case.

A gentleman fractured his skull, and remained fifteen minutes insensible; became sensible but could not speak for seven days; for twenty-eight days could not speak distinctly and used one word for another. In six weeks he was considered well, with a depression of the lower posterior part of the left parietal bone, two inches and a half long, and one and a half broad, and three quarters deep, which was removed at the end of three years, the increase of symptoms making it necessary; they all went off, and he continued well.

On the anterior lobes of the brain both anteriorly and laterally, with thickening of the pia mater, produced spasms in the lower extremities and total loss of memory; so that the person did not know what he had done a few hours before, although in other respects in health.

The frontal and parietal bones were one-third of an inch thick.

There was an ossification in the falx of the dura mater near the crista galli, one inch and a half long, three quarters broad; another near the tentorium three quarters of an inch

long, half an inch broad, and three quarters thick. The tunica arachnoides and pia mater were thicker than the dura mater. The processes of the pia mater firm; the smaller arteries in the medullary substance carried red blood, and two ounces of water were found in the ventricles.

The person had been thirty-five years in India.

Pressure on the lower and lateral portions of the anterior and middle lobes of the brain, has produced head-aches, general wasting, irregularity in the action of the bowels; the feel of inability to swallow, and great distress in the act of swallowing, with much general irritability. The pressure was caused by numerous small exostoses, particularly from the lower portions of the parietal bones, some longer than others and sharp at the point; the longest one-third of an inch.

Pressure from the frontal bone having become twice its natural thickness, and a portion of the dura mater immediately under it four times thicker than common, produced loss of memory, occasional fits of insensibility lasting several hours, returning nearly every six months from excess in wine or anxiety, leaving delirium, which gradually went off.

Pressure from thickening of the skull, at the cinciput, from fracture, in six weeks, from excess of wine and fatigue, produced apathy and pain in the head; this continued four weeks, delirium came on, and three weeks without articulation; but in three months recovered partially, but the apathy and dejection continued to the end of twelve months.

In the thirteenth month, he had much pain in the part upon touching it, his spirits became violently high, and he

was declared insane; but in no other point than lust, shameless respecting every woman.

In this state, removing the thickened bone, which was double the natural thickness, gave great pain. When the longitudinal sinus was accidentally wounded by the saw, he became immediately perfectly rational; upon the wound healing, the former symptoms returned, but bleeding and purging removed them, and he continues well.

Pressure from an uniform thickening of the frontal bones, so as to flatten the anterior lobes cerebri, impaired the mind nearly to idiotism.

In some of these cases the memory admitted of the persons playing at cards, although the moment the game was over, all traces of recollection respecting the game or having played at all, were gone.

So common is this thickening of the frontal bone from exposure to the sun during a long residence in India, that I have found the diminution of the memory in all its different degrees, in different individuals.

SECTION VIII.

The Effects of Pressure on the Brain from Tumours.

An hydatid, or watery tumòur, imbedded in the substance of the right hemisphere, of the brain was attended with violent head-aches, and occasional fits similar to those of apoplexy. It was the size of an orange, had firm coats, in which was contained a limpid fluid in the quantity of four ounces. The sides of the lateral ventricles were closely pressed together.

A tumour in the substance of the posterior lobe cerebri, was attended with derangement of the functions of the stomach and bowels, double vision, and afterwards loss of sight.

The tumour was of the steatomatous kind, just above the tentorium, of the size of a turkey's egg, so as to raise up the posterior part of the lateral ventricle. The complaint, till just before death, was mistaken for worms.

A tumour pressing on the left hemisphere, brought on settled melancholy, drowsiness after dinner, requiring being carried into the air, which took it off, but it returned on coming back to table. The tumour was of a soft nature, the size of a filbert, attached to the left side of the falx of the dura mater, a little above the tentorium, pressing upon the left hemisphere of the brain.

The pressure of a tumour in the left ventricle produced epileptic fits, soreness in the throat, and a great pain in the act of deglutition.

The tumour was of a soft steatomatus structure, the size of a walnut, but adapted in its shape to the form of the ventricle.

Pressure from a tumour in the tuberculum annulare, and water in the ventricles, produced pain in the head, stumbling in walking, the mouth drawn on one side, loss of sight of one eye, although the pupils were not affected; dullness in hearing, difficulty in swallowing, so as to die starved, with all the mental faculties entire. The tumour was of the size of a walnut, composed of a suety matter; four ounces of water were found in the ventricles, and the tunica arachnoides was unusually thickened.

Pressure from a tumour two inches long and two broad imbedded in the right lobe of the cerebellum, immediately under the tentorium, to which it adhered: the tunica arachnoides without moisture, and three ounces of water in the lateral ventricles, brought on a fit, which left the person speechless, but did not deprive him of his senses.

With these observations on the effects of pressure in different ways upon the brain, I shall conclude this Lecture; for although many facts remain upon my register on this important subject, the principal effects have been explained, and I am unwilling to load your memories. They are not to be run over like the beads upon a rosary. Indeed the explanation of many of the separate facts would furnish materials for a Lecture. I have, however, given you an example respecting what appears to me the best mode of coming at a knowledge of the uses to which the different structures of the brain are applied. The progress I have made in forty-six years is small, but may be depended upon, and can serve as materials for those who follow me with equal opportunity and stronger intellect to produce more brilliant results.

The facts I have stated will stand their ground as long as reason holds her seat, and long after the doctrines of a Gall and a Spurzheim are consigned to the regions of unrestrained imagination and wild enthusiasm.

PART II.

Injuries to the Brain and Spinal Marrow.

SECTION I.

Loss of Substance of the Brain.

A PORTION of the medullary substance of the brain, to the amount of half an ounce, from the anterior lobe, in a boy five years old, from fracture of the skull, produced no symptoms beyond those common to fracture.

When he went to school, his memory and quickness exceeded those of his brother of nearly the same age.

Loss of a portion of one hemisphere from similar accident was attended, for twenty-four hours, with difficulty of swallowing and delirium; after that period these went off.

The substance of the brain shooting out, in consequence of a wound from the trepan, was not attended with sensation, while the edge of the wound in the pia mater was exceedingly sensible. The fungous shooting out appeared to be from the small vessels of the pia mater. The patient died in three days.

Ulceration of the anterior lobe, as low as the covering of the lateral ventricle, but not communicating with it, produced paralysis of both arms—the brain was wounded by the trepan.

SECTION II.

Suppuration in the Cavities of the Brain.

When the cavity between the dura mater and tunica arachnoides is opened, suppuration takes place upon the surface of the tunica arachnoides, producing coma, delirium, and death.

Suppuration between the skull and dura mater, the quantity of matter, a tea-spoonful, produced watchfulness, sickness, clammy sweats, irregular pulse, incessant rambling in conversation; these symptoms went off upon removing the bone.

Suppuration in the cornu of the right lateral ventricle, produced delirium and convulsions.

Pus under the tuberculum annulare produced vomiting and delirium.

The dura mater is little liable to suppuration, or even to inflammation, although the contrary has been believed to be the case; and after the operation for the trepan, Surgeons have been always advised to smooth the edge of the bone to prevent injury to the dura mater. This membrane is so little in danger, that when it is forced up against the skull by the pulsations of the arteries in the brain, all the irregularities on the edge of the lower table are removed by the repeated strokes fairly wearing them away.

When the upper surface of the dura mater is injured by the saw in trepanning, coagulable lymph is thrown out, which fills up the hole made in the bone, and prevents the new growth of bone. When no such injury takes place,

the bone is restored by a membranous covering, which afterwards becomes bone.

When the dura mater is cut through by the teeth of the saw, coagulable lymph is thrown out upon its under surface, of nearly the thickness of the membrane itself, adhering closely to it, while pus is found lying upon the tunica arachnoides, immediately under it. The symptoms are the same as when suppuration takes place from any other cause; but this fact disproves the assertion that the dura mater has a lining from the tunica arachnoides, the two surfaces being differently constructed.

SECTION III.

Injuries to the Brain itself, not producing Suppuration.

The substance of the brain appears neither to be capable of sensation or suppuration. A ball from a musket, lodged in the anterior lobe cerebri, was found after death, which took place from another cause, surrounded by a glary substance, extending to the distance of half an inch all round the ball.

A deep wound into the brain, made by the explosion of a copper powder horn forcing a piece of the copper, three inches long, and more than one broad, through the eye, several inches into the brain, produced no sensation in the brain, nor in any way affected its functions; the person lived several days. He became insensible three hours before death.

The right hemisphere of the cerebrum was penetrated by a ball carrying before it several pieces of the skull; the

ball was extracted, and a slight watery discharge oozed from the external wound, which remained open. The only symptoms produced were head-ache and numbness of the left side. The person did his duty as a naval officer from China to England.

A year after the accident, it was attempted to extract the pieces of bone, which brought on an attack of inflammation of the pia mater, followed by death.

After death it was found that several portions of bone had remained covered with a glary substance, for a year, without producing any pain or other bad effect.

SECTION IV.

Effects of Malformation in the Brain.

In a case in which the tuberculum annulare had so hard a texture as with difficulty to be cut with a knife, a considerable quantity of earthy particles being intermixed with the medullary substance of the crura, and other parts of the cerebellum; the cerebrum and upper part of the cerebellum unusually soft; the effects were, the boy had been an idiot from his birth, could neither walk, speak, or understand what was said, went often three days without food. At sixteen, when he died, was no bigger than a child of three years, except the head, which was as large as it is usually at twelve. The cranium was not completely ossified, the fontanelle being still of a large size.

SECTION V.

Effects of Injury to the Medulla Spinalis.

Pressure upon the medulla spinalis in the neck by coagulated blood produced paralytic affections of the arms and legs, all the functions of the internal organs were carried on for thirty-five days, but the urine and stools passed involuntarily.

A coagulum of blood, the thickness of a crown piece, was found lying upon the external surface of the dura matral covering of the medulla spinalis, extending from the fourth vertebra colli, to the second vertebra dorsi. The medulla spinalis itself was uninjured.

Blood extravasated in the central part of the medulla spinalis in the neck, was attended with a paralytic affection of the legs, but not of the arms. The sixth and seventh vertebra colli were dislocated; the medulla spinalis externally was uninjured; but in the centre of its substance just at that part there was a coagulum of blood nearly two inches in length.

In a case where the substance of the medulla spinalis was lacerated in the neck, there was a paralysis in all the parts below the laceration; the lining of the œsophagus was so sensible, that solids could not be swallowed, on account of the pain they occasioned. The seventh vertebra colli was fractured, and the medulla spinalis passing through it, was lacerated and compressed.

Where the medulla spinalis in the back was completely divided, there was a momentary loss of sight, loss of memory

for fifteen minutes, and permanent insensibility in all the lower parts of the body.

The skin above the division of the spinal marrow perspired, that below did not.

The wounded spinal marrow appeared to be extremely sensible. The spinal marrow within the canal of the sixth vertebra dorsi was completely destroyed by a musket-ball.

The person lived four days.

SECTION VI.

On the Functions of the Nerves, illustrated by the Effects produced on their Action by accidental Injury or Disease.

Were these Lectures given only to the general philosopher or physiologist, such observations on nerves would be misplaced, but when I consider that the greater part of my audience are studying the healing art, and that all the knowledge I have myself obtained respecting the nerves has been from the consideration of them, when their funotions have been deranged; I am unwilling to withhold from those who hear me the results of many years' experience, more especially as it will lead to the most rational mode of treating the nerves when diseased, and a detail of the facts will make a stronger impression upon your minds, than simply giving the conclusions I have deduced from them.

When the nerves of the tongue near the point are bruised considerably, in consequence of being bitten, the same effect is not produced as when the nerves of this part are less violently acted upon; after the immediate pain, no unusual

sensation in the part is produced, but the sense of taste is entirely destroyed. Of this I shall mention the following case that came immediately under my own care, and as it settles a material point in physiology, that the palate makes no part of the organ of taste, and one still more important in surgery, that the tongue is not composed of a very delicate structure, and may have a portion of it removed by the knife without bringing on considerable inflammation, it is very proper that it should be put upon record.

A gentleman had his tongue accidentally bitten with great violence; the local pain was very great, but unattended with swelling of the part or other symptoms. Upon eating, he was surprised to find that he had entirely lost the sense of taste. This alarmed him very much, and led him to consult me upon the subject. I examined the tongue a fortnight after the accident. It had the natural appearance, but the tip was completely insensible, and was like a piece of board in his mouth, rendering the act of eating a very unpleasant operation. I saw him three months afterwards, and it was still in nearly the same state.

From this case it appears that the tongue itself is not particularly irritable; but the nerves passing through its substance to supply the tip, which forms the organ of taste, are very readily deprived of their natural action; this probably arises from their being softer in texture than nerves in general, and, in that respect, resembling those belonging to the other organs of sense.

There was another circumstance in this case which very particularly struck my attention, viz. that a bruise upon the nerves of the tongue, sufficient to deprive them of the power

of communicating sensation, was productive of no inflammation or irritation in the nervous trunk, so as to induce spasms, which too commonly occur from injuries to the nerves belonging to voluntary muscles.

I am therefore led to believe, that the nerves supplying an organ of sense, are not so liable to such effects as those which belong to the other parts of the body, being of a different texture.

The small degree of mischief which was produced, and the readiness with which the nerves had their communication completely cut off, were to me new facts, and encouraged me in the following case of fungous excrescence from the tongue, which bled so profusely as at times to endanger the patient's life, and never allowed him to arrive at a state of tolerable health, to attempt removing the part by ligature.

John Weymouth, eight years of age; was admitted into St. George's Hospital, on the twenty-fourth of December 1800, on account of a fungous excrescence on the right side of the anterior part of the tongue, which extended nearly from the outer edge to the middle line at the tip. He had been a year and a half under a surgeon, who had removed the excrescence by ligature round its base; but when the ligature dropped off, a violent hemorrhage took place, and the excrescence gradually returned.

Attempts were made to destroy it by caustic, but hemorrhage always followed the separation of the sloughs; so that after ten trials, this mode was found ineffectual.

It was also removed by the knife ten different times, but always returned.

From this history, I was led to believe, that the only mode of removing the disease was taking out the portion of the tongue upon which it grew. This was a case in which I felt myself warranted in making an attempt out of the common line of practise, to give the patient a chance of recovery; and from the bite having produced no bad consequences on the neighbouring parts, I was led to remove the excrescence in the following manner:

On the twenty-eighth of December, I made the boy hold out his tongue, and passed a crooked needle armed with a double ligature directly through its substance, immediately beyond the excrescence. The needle was brought out below, leaving the ligatures; one of these was tied very tight before the excrescence, the other equally so beyond it, so that a segment of the tongue was confined between these two ligatures, in which the circulation was completely stopped. The tongue was thin in its substance, and the boy complained of little pain during the operation.

Thirty drops of laudanum were given to him immediately after it, and he was put to bed. He fell asleep, continued to dose the greater part of the day, and was so easy the next day, as to require no particular attention. On the fifth day from the operation, the portion of the tongue came away with the ligatures, leaving a sloughy surface, which was thrown off on the eleventh day, and was succeeded by a similar slough; this separated on the fifteenth day.

The excavation after this gradually filled up; and on the twentieth day, it was completely cicatrized, leaving only a small fissure on that side of the tongue.

Encouraged by the result of this case, I was led to perform a similar operation upon a person at a more advanced period of life. A woman, forty years of age, was admitted into St. George's Hospital on the twenty-fifth of December 1801, on account of a tumour the size of a pea, situated on the right side of the tongue near the edge.

The history of the case was as follows:

A small pimple appeared and gradually increased, without pain; the only inconvenience was, that it affected her speech, and when bruised by the teeth bled freely. The operation was performed on the seventh of January 1802, in exactly the same manner as has been already described. It produced a considerable degree of salivation, which was extremely troublesome, (much more so than the pain the ligatures produced,) and continued till the slough came away. The ligature nearest the root of the tongue separated on the sixth day; the other on the seventh; and in three days after the separation of the second ligature, the wound was completely skinned over.

A third case of this kind came under my observation, in which there was a small tumour, in the substance of the tongue, about the size of a pea, which gave me the idea of its being of that kind which might terminate in cancer. The patient was a gentleman of about forty-one years of age. Upon examining the tumour, I told him of my alarm respecting its nature; and at the same time added, that I was very ready to remove it, should it be the opinion of other practitioners that such a step was adviseable; and my experience in two former cases led me to believe it might be done with safety.

I therefore advised him to consult other medical practitioners of reputation, and acquaint me with their opinion. It was found to coincide with mine, which induced the patient to decide upon having the tumour removed.

The operation was performed on the twenty-eighth of December 1802. The needle pierced the tongue an inch beyond the tip, a little to the right of the middle line of the tongue; and the space between the two ligatures, when they were tied at the circumference of the tongue, was fully an inch. The tongue was thick and broad, so that the mass included by the ligatures was such as to make it difficult to compress it. The operation gave considerable pain, of a numbing kind. Immediately after the operation, the part included became dark coloured, particularly towards the middle line of the tongue. A salivation took place. The next day the pain and salivation were great, and the patient could not swallow; but on the day following he could take broth, negus, and other fluids. On the sixth day from the operation, the slough became loose, and the least motion of the tongue gave great pain.

Upon examining the slough, there was a small spot which looked red, and was surrounded by a dark surface; this was towards the right side. Upon further examination, it appeared that the ligature to the right had not completely deadened the part of the centre, in which an artery had its course. This accounted for the red spot, as well as for the pain the patient suffered; and led me, on the seventh day, to disengage the ligature on the left, (which was almost completely separated) by means of a pair of scissors, and pass another ligature through the groove to the opposite

side, and tie it over the part not completely deadened. This gave great pain for a few hours, which was relieved by the use of tincture of opium. On the eighth day, the patient had less pain than on any preceding day, and less salivation; and, on the ninth, the whole slough came away.

On the thirteenth, the tongue had so much recovered itself, that there did not appear any loss of substance whatever, only a fissure of half an inch in depth in the anterior part of it; and, as that now seemed to be exactly in the centre, there was not the smallest deformity.

When the common nerves of voluntary muscles are injured, they produce symptoms varying exceedingly according to the peculiarities of the constitution, and the parts with which they are connected.

In proof of this, I shall mention two cases of injury to the nerves of the thumb; in one of them a lock-jaw was the consequence.

In the other spasms went up to the head, but instead of fixing upon the muscles of the jaw, went directly to the brain, producing fits similar to apoplexy, followed by paralysis.

Case of Lock-jaw from Injured Nerve.

A lady of a very irritable habit was overturned in her carriage, the right thumb was much hurt, the parts immediately became tumid, and the skin over the metacarpal bones of the fore finger, to the size of a shilling, sloughed off, fourteen days after the accident; on bending her fingers violent spasms took place in her thumb, which extended to

the lower jaw; these were very painful, and the jaw could not be opened more than to receive a tea-spoon. In fourteen days more, the jaw began to be less rigid, and for the following month, there were only two or three spasms daily in the thumb, attended with pain; these all terminated in the muscles of the jaw.

At this time the sore on the hand healed, after which there were no spasms.

Case of Spasms and Fits of Insensibility from Injury to the Thumb.

A gentleman thirty-six years old, while riding in the country, fell with his whole weight upon the end of his thumb, against the pommel of the saddle. The part swelled and became very painful. A few days after he hurt it again, which prevented the swelling from subsiding, and it continued uneasy and enlarged for three or four months.

It afterwards got well, but the motions of the thumb were not always under the command of the will; so that he was sensible, in the years 1797 and 1798, while writing, of finding a difficulty in forming particular letters.

On the evening of the sixteenth of October 1799, which was cold and damp, he was travelling in a post chaise with two other persons, and let down the window to speak to the driver. A cold wind blew directly into the carriage, and he endeavoured to pull up the window; but not seeing the glass rise, he looked down, and his hand, instead of pulling up the window, was lying upon his knee.

The thumb was bent in towards the palm of the hand; a spasm came upon the muscles of the arm, making them bend the elbow, and immediately he became insensible; in a quarter of an hour he perfectly recovered himself. Some hours after, upon bending his thumb, to show what had happened to him in the carriage, there was a return of the same attack, which also rendered him insensible for a few minutes.

From this time he had no return of these attacks for nine weeks; at the end of which period, on the eighteenth of December 1799, he was waving his hand over his head with a degree of eagerness, as a sign for some people to make haste and follow him; this exertion made the thumb contract towards the palm of the hand, and he fell upon the ground in a state of insensibility. This attack went off, as the others had done; he had another in the evening; and, in the course of the next day, two more, equally violent.

As the motion of the thumb was the first symptom in all these attacks, the assistants were led to contrive a glove, the front of which was strong enough to resist the motion of the thumb, and keep it in its place; while this was kept on the attacks were less frequent. A ligature was then applied round the fore arm; when the thumb was beginning to be agitated, this was tightened, and the spasms were found to be arrested at the ligature, and of course lessened in their violence.

From this time, a tourniquet was kept constantly upon the fore-arm; and a person was always in readiness to tighten it, the moment the spasm was expected, which was always preceded by a general feeling of uneasiness all over the

body; as soon as the spasm went off, which it did instantaneously, the tourniquet was loosened.

The spasms in the thumb and fore-arm returned frequently, and at irregular intervals, generally every three hours, sometimes oftener, and once did not come on for thirty-six hours.

On the third and fourth day, electricity was tried, with a view to relieve them; sparks drawn from the thumb produced tremors in the muscles which went to the thumb.

An electric shock through the ball of the thumb brought on a very severe spasm in the arm; but neither sparks nor a shock through the other thumb produced any sensible effect.

On the twenty-ninth of December I first saw the patient; and upon watching the symptoms for three days, made the following observations upon the complaint:—

That the beginning of the attack was some involuntary motion of the thumb and fore-finger; and, therefore, the disease appeared to be in the branch of the nerve which supplies these two parts, called by Winslow the median nerve.

That the progress of the spasms was in the direct course of the trunks of the median nerve up to the head.

That compressing the parts in the course of that nerve, when it was done before the spasms had reached them, always arrested their progress; but, when once the muscles had become convulsed, or agitated, the same compression had no effect in stopping the progress of the spasms.

The mode in which the spasms were propagated along the course of the nerves was as follows:—

Five or six tremors took place in the flexors of the thumb and fore-finger; then similar convulsive motions affected the muscles of the fore-arm; soon after the muscles of the arm were thrown into the same kind of action; afterwards the pectoral muscle, and scaleni of the neck; the muscles of the lower jaw were probably in the same state, although their action was not within the notice of the by-standers. The head was pulled forcibly to that side in quick successive motions, and in a second or two the whole ceased; the parts became tranquil, the insensibility went off, and the patient recovered himself: there was, however, a general feel of languor and distress over the whole body before the recovery.

From these observations, the disease appeared to be decidedly in the inferior branches of the median nerve; and the irritation was conveyed along its course, from its terminations in the thumb and fore-finger, to the origin in the brain.

It was proposed to divide the nerve, as it passes from under the annular ligament of the wrist towards the thumb, to cut off the communication between the diseased extremities and the trunk of the nerve, and so put a stop to the progress of the irritation which constituted the disease.

That such an operation might be attended with success, was not only rendered probable from reasoning, but the performing it was fully justified by the relief which had been experienced for a considerable time from a similar operation in some cases of tic doloreux; a disease, in many respects, of the same nature with the present.

All these circumstances were explained to the patient, who, from a desire of obtaining relief, consented to have the nerve divided.

This was done on the first of January, 1800, in the following manner: — the nerve, as it passes from under the annular ligament, towards the thumb and fore-finger, was laid bare for above an inch in length, it was then detached from its lateral connections, and, in this exposed state, a probe-pointed bistoury was passed behind it, and the nerve was raised upon the edge of the instrument, so as to be distinctly seen by the different medical gentlemen present, before it was cut through. As soon as it was divided, the two cut ends retracted from one another, to a considerable distance.

This retraction was very unexpected, as the nerve was disengaged from the cellular membrane, and no other part had been divided, whose action could make the portions of the nerve recede.

That nerves, when divided, do retract, is well known in the practice of surgery, but this effect has been usually attributed to the contraction of the neighbouring parts, as the cellular membrane and blood-vessels, with which the nerves are connected.

As none of these causes could produce the effect in the present instance, it was natural to suppose, that an independent action existed in the nerve itself, which had been so much increased by the influence of disease, as to become unusually great; and, therefore, the retraction was more distinctly seen than in a healthy state of the body.

The moment the nerve was divided, there was a spasm over the whole body, and a momentary insensibility. The blood-vessels, divided in the operation, were not secured by ligatures, but allowed to stop of themselves, to give the wound every chance of healing by the first intention. The edges of the skin were carefully brought together, and kept in that state by compress and bandage, to promote as much as possible the union.

For eight hours after the operation, the parts were perfectly quiet, and there was no spasm.

The wound then began to feel hot, as if a red hot coal had been applied to it. To relieve this sensation, the outer bandage was loosened, and immediately there were twitches in the nerve, which soon went off. The patient felt himself generally unwell, extremely nervous and irritable.

Fifteen hours after the operation he had a violent spasm, which went along the arm to the head, but did not affect the brain. In an hour there was a second attack, at which I was present. The pulse one hundred and five in a minute, the tongue white, a great deal of general irritation, nervous twitches all over the body, but in the greatest degree in the arm and leg of that side. The stiff-fronted glove was now put on to confine the thumb.

Twenty-four hours, or one day after the operation, the first dressings were removed; the thumb was much swelled, and no union whatever had taken place; the spasms returned every five hours, but were less violent.

The second day, there was an abatement of the symptoms, and the spasms did not affect the brain; they did not admit

of being stopped by the pressure of the tourniquet, as they had been before the operation.

The third day, there were intervals of ten hours between the spasms; and, in the night, they did not extend beyond the elbow.

The fifth day, suppuration took place in the wound: the swelling in the hand was much abated; and the patient was able to dress and shave without spasm, having only twitches in the fingers, and tremors in the fore-arm.

The sixth day, there was a burning pain in the hand, and a numbed heavy feel in the thumb and fore-finger, similar to what the patient recollected to have felt four years before, when he hurt his thumb.

The seventh day, the patient awoke with great pain in the hand, succeeded by a violent spasm, which passed up to the head, although the tourniquet had been previously tightened: after this, he had a spasm for sixteen hours.

The eighth day, the hand was less swoln and less painful, and he had only two spasms in twenty-four hours.

The ninth day, the swelling had subsided, and the twitches ceased: in thirty hours there was only one slight spasm, which did not go beyond the wrist.

The sixteenth day, the wound was entirely healed; and as there had been no return of spasms, the patient was considered as well.

On the twenty-fourth day, which was a fortnight after the spasms had ceased, at nine o'clock in the morning, he was awakened by a violent spasm, which passed directly up to the head, and affected the brain, producing insensibility: this was the only time the brain had been affected since the operation.

Two days previous to this attack, he had a violent diarrhœa; and, on the preceding day, had undergone unusual fatigue.

The tourniquet, which had been laid aside, was now applied, and, for the greater security, two were placed in the fore-arm, and one upon the arm itself. At six in the evening, there was another spasm, attended by insensibility, although the tourniquets had been tightened. The hand was found swelled, as well as the wrist; and the cicatrix formed a hard welt, tender to the touch. This hard state of the cicatrix, in which the ends of the divided nerve were included, appeared to be a probable cause of the return of the spasmodic attacks.

The twenty-fifth day, the pulse was one hundred in a minute; and every two hours, there were slight spasms.

The twenty-sixth day, there were eleven spasms, at irregular intervals, in twenty-four hours; eight of which went up as high as the head. As the spasms were not stopped by the tourniquet as before, it was proposed to make the pressure directly upon the nerve; this was done by placing pieces of cork in the course of the nerve, and confining them there by the band of the tourniquet, so that, when the screw was tightened, the cork was pressed down on the nerve. This pressure gave great pain, and, instead of arresting the progress of the spasms, seemed rather to increase their violence, it was therefore left off.

The twenty-seventh day, the pulse was only between eighty and ninety in a minute: there were seven spasms; all of which were arrested by the first or second tourniquet.

The spasms went on with very little variation, till the thirty-ninth day, at six o'clock in the morning, when he was seized in his sleep with a violent spasm, attended with insensibility, and convulsions over the whole body; these lasted for twenty minutes. After his recovery, the hand was found much swoln, and the welt formed by the cicatrix was painful. In the course of the forenoon he was well enough to bear going out in the carriage; the fresh air always proving very grateful to him.

From this time, the swelling of the hand and the hardness of the welt diminished; and the spasms were less violent, and more seldom.

On the forty-fifth day, there was only one slight spasm in twenty-six hours. In this state he went into the country; and, for the first fortnight, the spasms diminished, but afterwards became more violent.

The return of the spasms, after the wound had been healed, made it evident, that the operation of dividing the nerve had not answered the purpose which was expected from it.

The failure probably arose from the wound not healing by the first intention; the consequent inflammation rendered the cut end of the nerve uncommonly irritable; and, in this state, the confinement in the hard thickened cicatrix rendered it liable to be stretched by every motion of the thumb, so as to bring on spasmodic contractions.

From this time, the patient was not under my direction; but I understand, that he tried the effect of large doses of opium, which did not afford relief. He was then induced to employ electricity; and an electric shock, passed through

the head, produced instant death. This event took place five months after the operation was performed.

Case of Injury to the Nerve of the Ankle affecting the Brain.

A gentleman, nineteen years of age, had a kick from a horse on the right foot, near the bend of the ankle; the sensation produced was a violent jar in the teeth and head.

The spot kicked was the size of a crown-piece, and did not recover its natural sensations.

The accident happened in the year 1800.

He went to Vienna, and, in July, 1801, in leaping from a considerable height, he kicked his foot against a post. This brought on a spasm, beginning in the foot, going up the leg, and lasting some time before it went off.

On the sixteenth of December, 1802, at ten at night, he felt a creeping sensation in the foot where the blow had been received; a slight spasm extended to the toes; in twenty minutes extended up the leg to the head, rendering him insensible, and then went off. In January, 1803, in going down stairs, he twisted his ankle, at ten at night, and brought on spasms; which extended occasionally to the body, and sometimes to the head; produced suppression of urine, requiring it to be drawn off, till the sixth day, when these symptoms abated; but the whole right side became paralytic, and he was deaf of the right ear. On the tenth, the right side began to recover: he could hear a little with that ear, and see with the eye: on the twenty-sixth of January, all the symptoms had in a great measure gone off.

On the seventh of February the ankle joint was first confined by a steel sandal which I had directed, to prevent all lateral motion. This I suggested, on the principle that the nervous spasms were brought on by the least agitation of the nerve, which had never recovered from the effects of the original injury. This instrument was worn night and day, and he never afterwards had a return of spasm; it was continued for eighteen months before the nerve completely recovered itself; for during the whole of that period, if it was left off, the motion of the ankle joint produced uneasiness, and it was immediately put on again. Since that time he never has had a return, a period of more than twenty years.

In a case of injury to the sciatic nerve, spasms came on upon going to bed, so that the person was deprived of rest for nine months. Upon being consulted, I found that by steadying the limb, so as to prevent the bending of the knee, the spasms were completely prevented. No medical treatment had been of the smallest use; the only essential benefit was produced by keeping the limb from motion. In a case of injury to the posterior crural nerve in the thigh, the patient suffered greatly from spasms; they were brought on by lying down in bed, having the habit of sleeping on his back. After various medicine had been tried, without benefit, when I was consulted, I directed the use of the cold hip-bath, which included the part where the nerve had been injured, and advised never to straighten the body: by following this plan he was able to sleep all night, and got quite well.

LECTURE V.

On the Teeth, Stomach, and Spleen.

[Continued from the Twelfth Lecture in the First Volume.]

THE slow progress of Comparative Anatomy, will appear to arise from a want of zeal in the pursuit, more than from a difficulty in procuring the materials.

In the former volume, Lectures X., XI., and XII., I published all the facts upon the subjects to be noticed in the present Lecture, that were not, to my knowledge, put upon public record; and in the short period of eight or nine years, by applying for assistance to my different friends, who had the opportunities of collecting in natural history, I have made sufficient accession to my stock of information, to publish another Lecture. In doing so I shall describe the teeth and stomach of each animal, where I am enabled so to do, under distinct heads.

On the Teeth of the Delphinus Gangeticus.

It is the teeth only of this rare animal that have come within my observation, and I regret that I am unable to give any account of the stomach.

The general principle upon which the stomach of the whale tribe is formed being known, makes it improbable that there should be any great deviation from the usual structure in this particular species.

A description of the external figure of the delphinus gangeticus, by the late Dr. Roxburgh, is published in the seventh volume of the Asiatic Researches for the year 1781: this contains no further account of the teeth than that the number is one hundred and twenty, thirty on each side of each jaw, nor have I met with any more particular description of them in other publications.

In the second volume of Dr. Shaw's General Zoology, in which the whale tribe is mentioned, he says, a narrow-snouted dolphin is supposed to inhabit the Indian seas; but is only known to us from specimens of the head and jaws.

The jaws are extremely narrow, the teeth small, not numerous, distant, and shaped somewhat like the molares of quadrupeds.

This description corresponds so ill with the teeth of the delphinus gangeticus, that it would almost induce us to believe that it is meant for those of another animal.

A specimen of the upper and lower jaw of the delphinus gangeticus was given to me, seventeen years ago, by the late Sir Joseph Bankes, and has been deposited ever since in the

Hunterian Collection; but it was only the other day that an accidental reference to the Asiatic researches led us to discover the animal to which they belong. The singularity of the form of the teeth made the specimen always a remarkable object, and now the animal is known, a description of them becomes interesting and highly deserving of attention.*

The jaws and teeth form the most remarkable characters of this species of delphinus; and a knowledge of them will not only interest the naturalist and comparative anatomist, but enable the geologist, when fossil teeth are found of this shape, readily to determine the species of animal to which they had belonged.

These teeth, as is common in those of the whale tribe, have the first rudiments formed in the gum, from which the tooth grows in both directions, upwards through the gum in the form of the point of a flattened cone, which is coated with enamel, and downwards towards the jaw, increasing considerably in breadth but not in thickness, till it is at last imbedded in the substance of the jaw itself: the lower portion has no enamel.

The change that takes place in the form of the tooth, as it wears away from long use, is more remarkable than in most other teeth; for the perfect tooth has a tolerably sharp enamelled point, while the worn one has a curved, blunted, cutting edge. The teeth in front of the jaw are more like the incisores in other animals. The whole number in both jaws exactly corresponds with that given by Dr. Roxburgh, and identifies these jaws as belonging to the animal which he has described.

* Plate XVII.

On the Teeth of the Seal.

The extraordinary difference in size between the skulls of the same species of animal at different stages of their growth, and the difference in the form of the teeth, have long attracted my notice; and thirty years ago, when I was preparing to lay before the Royal Society, in Mr. Hunter's name, some account of the fossil skulls of wolves and bears, found in the caves met with in the principality of Bayreuth in Germany, I had drawings made of the skulls of seals explanatory of this curious circumstance, showing that they were not peculiar to the skulls of bears, but equally common to other animals. My time has since been so engaged in other enquiries, that I entirely lost sight of this subject, and it was only brought back to my recollection by the consideration of the new species of rhinoceros discovered by the missionary, Mr. Campbell, in the interior of Africa. Any observations of this kind will have much more value at present, and attract the attention of those who are making so great a progress in the Science of Geology, than they would have had, at the time I mention, when geology was little known in this country.

Were it not within my own knowledge that the skull which is represented in the annexed plate*, belonged to the great seal so many years deposited in the British Museum as a stuffed specimen, and the skull, after the skin had been destroyed by insects, was given to the Hunterian Collection, I could not have credited that it was the skull of a seal, it is

* Plate XVIII.

so unlike the skull of an old seal with a grey beard* which had been known by the people of the neighbourhood to come to a particular rock in the sea, near some of the Orkney Isles, for thirty years: it had become so well known, that a friend of mine, a Kentish Baronet, went to the Orkneys for the direct purpose of shooting it, prepared with a cask to convey the bones to London, as a present to Mr. Hunter, and they are deposited in this Collection.

The skulls of all young animals differ very considerably from those of old ones, in wanting the impressions which are afterwards made by the muscles, particularly those employed in mastication, and those that support and raise the occiput; but the teeth, after the first are shed, may be generally recognized, but in this respect, the small seal after it has become old, has teeth so unlike those of the large one, that unless they are accurately examined, the slight traces of resemblance would be overlooked.

When the teeth of both these species of seal are compared with those of a seal brought from new Georgia, near the ice that extends from the south pole, an engraving of which is annexed†, the difference will be found so great that we must remark here, as I have done elsewhere, that the kind of food appears to decide what the structure of the teeth is to be, of animals of the same tribe, when placed on different and very distant portions of our globe.

Since the publication of my first volume, I have had an opportunity of examining the grinding teeth of the elephant at a very early period of their growth, the animal being only a week old; and although what I stated respecting the

* Plate XIX.

† Plate XX.

nature and mode of growth of the three substances of which it is composed, was then very much controverted, I have now the power of demonstrating, in preparations, the truth of what I then asserted.

On the Teeth and Stomachs of the Dugong and Manatee.

Two of the most extraordinary animals in nature having been brought within my observation nearly at the same time, the dugong from the eastern seas, by my friend, Sir Stamford Raffles, Lieutenant-governor of Bencoulen, and the manatee, an inhabitant of the mouths of the great rivers in the island of Jamaica, one of which is called Manatee River, by the kindness of the Governor of Jamaica, the Duke of Manchester, I shall describe their different organs, in the parts of these Lectures to which they belong, as objects of Comparative Anatomy. They are both inhabitants of the shallow waters near the shores of the ocean, or of the great rivers that open into the sea, and feed upon the vegetables that grow in these situations. Their teeth and stomachs bear a resemblance to one another.

This tribe of animals differs from all others in the form and structure of their teeth and stomachs, and forms a curious intermediate link, in these respects, between the hippopotamus, whose food is of a similar nature, and the tapir and rhinoceros.

I have had opportunities of examining the skulls of the dugong before the milk tusks were shed, and after I had finished my description of them, I fortunately received another skull, in which the permanent tusks were formed.

The milk tusks, in two skulls I examined, were in the same stage of growth, but further advanced, than in the skull described by Cuvier, of which he has given an engraving in the thirteenth volume of the Annales du Museum d'Histoire Naturelle; and also in the fourth volume of his work entitled Recherches sur les Ossimens Fossiles de Quadrupeds.*

In comparing the teeth of these specimens together, I had no doubt of their being the milk tusks.

My first examination was respecting the length of the tusks, the points of which were the only parts exposed. For this purpose the bony canal, in which the tusk is contained, was laid open, and the tusk was removed from its socket, and a longitudinal section afterwards made of it. Its substance was found to be solid, showing that it had arrived at its full growth, and was therefore a milk tusk; at the posterior extremity there was a shallow cup composed of the same materials, which appeared to be no part of the tusk itself, but, as it were, fixed to the end of it. This was contained in a cavity, adapted to it, in the skull; but upon the upper surface, the bony table of the skull was entirely removed to some extent by absorption, so that the shallow cup at the root of the tusk was exposed externally, giving the skull at that part a very extraordinary appearance. In both specimens the aperture through the external table of the skull is exactly of the same kind.*

In M. Cuvier's specimen there is no appearance of any breach in the upper table whatever, so that the process of absorption of the outer table of the skull, to make room for

* Plate XXI. † Plate XXII.

the formation of the permanent tusk, had not begun to take place.

When the section of this tusk was compared with a similar section of the milk tusk of the narwhal, and of the elephant, I found that in its internal structure it closely resembled them; and I noticed that the external surface in all of them was deficient in smoothness, when compared with the permanent tusks of those animals.

In the narwhal, the root of the milk tusk terminates in a rounded blunt end, behind which there is no appearance of any preparation for the formation of the permanent tusk; so that there is no evidence of that tusk *having its origin in a* cell similar to those of the dugong: but by comparing the place where the root of the milk tusk has its origin, with that of the permanent tusk in the same animal, for the two tusks in the narwhal come forward at such different periods of time, that this comparison may be made even when one permanent tusk appears to have arrived at its full growth, or nearly so; at which time the rudiments of the corresponding tusk have not begun to form; and the depth in the skull of the milk and permanent tusk exactly correspond.

As the permanent tusk in the narwhal begins to form in a direct line immediately behind the origin of the milk tusk, the great purpose of the milk tusk is evidently to open the road for, and to direct the course of the permanent tusk, till it is completely pushed out by it.

In the elephant, both of whose tusks appear at the same time, and whose skull increases in size much more rapidly than that of the narwhal, the permanent tusk has its origin

even farther forward than the milk tusk; but then it afterwards has an increase backwards in the space between the tables of the skull, which the tusks of the narwhal have not; and in this growth backwards, which is very slow, corresponding to that of the skull, absorption of the upper table previously formed, is produced to make room for it. In this way the sockets of the elephant's tusks, which are shallow when the animal is young, acquire an increase of depth as the elephant grows up, to give sufficient firmness to the skull, to support the tusks in the exertions afterwards made with them.

A similar absorption to what takes place in the upper table of the skull in the elephant, is shown to occur in the dugong; it is however probably at a different period of the animal's growth, as the milk tusk in the elephant is shed between the first and second year, and the absorption of the upper table many years after; but in the dugong, the absorption of the skull takes place just as the milk tusks begin to extend themselves beyond the gums, but the age to which the animal has at this time arrived is not known.

The use of the shallow cup, which appears to be an appendage peculiar to the milk tusk of the dugong, forming no part of the tusk itself, is for the purpose of receiving the point of the permanent tusk as soon as it is formed; so that as the milk tusk advances in the act of its being shed, the other may be directed forwards in the same course, which is a different one from that in which it set out.

The permanent tusks are broader and flatter at their points than the milk tusks, they point outwards, as in the

hog, and wear away in the same manner, but project to a small distance from the gum.

The facts that were brought forward in the Lecture upon the milk tusks of the narwhal, explained many circumstances in the natural history of that animal which were involved in obscurity; and the observations that are now made upon the tusks of the dugong, show that the milk tusks have hitherto been mistaken for the permanent tusks of this animal.

The grinding teeth, are not exactly similar to those of any known animal, but form an approach to the hippopotamus. They consist of two cones united together; but when a transverse section is made, there is no line of separation, the whole being uniform; the external crust is not enamel, nor is it the hardest part; a little within it, there is a narrow rim of a yellow colour, that describes an oval figure, much more dense than the rest of the tooth, although to the eye there is no apparent difference in its texture; all that is within this rim is soft ivory; so that these teeth in wearing down, always have the crown rendered concave.

The skull of the young dugong furnishes further materials respecting the teeth of this animal. It has two incisors in the upper jaw, immediately before the two milk tusks; these are more advanced in the gum than the tusks, and therefore would appear before them. The gum covering the alveoli is very thick; a ligamentous substance passed down from it into each separate opening attached to the rudiments of the

teeth they contain, to guide the points of the incisors and tusks in the right direction through the gum.*

The first or temporary set of molares which had been shed in the other skulls, were in this twenty in number, five on each side of each jaw. In the anterior scabrous projection of the lower jaw, were four regular sockets on each side filled with a ligamentous substance passing into them from the gum.

In the manatee, an animal so nearly resembling the dugong in its external appearance, as well as in its skeleton, and many parts of its internal structure, that it might be considered of the same species, were it not that the teeth have no similitude, the tusks are intirely wanting, and the molares are nearly the same as in the hog.

Before I enter upon a description of the stomach of the dugong, which has a great many peculiarities, I shall take notice of the whole of the upper part of the alimentary canal.

The tongue has two nipples at its base, covered with long villi.

The cheeks are lined with cuticle, with strong bristles, as in the hare and rabbit.

The œsophagus is lined with cuticle, which does not reach the cardiac orifice of the stomach, where the gastric glands are placed.

The stomach of the dugong differs from all those I have yet seen; for although some of its peculiarities are met with

* Plate XXIII.

in the whale tribe, the pecari, the hippopotamus, and beaver, even these are differently arranged.*

The cardiac portion is small for an animal living on vegetable food, and extends further to the left side beyond the entrance of the œsophagus than is usual; its form is more globular than the human. On the upper or small curvature to the left of the entrance of the œsophagus, quite at the extremity, are situated the gastric glands, forming a rounded mass, as in the beaver. The orifices of these glands are small and appear to be contained in a membranous bag, which has only one large aperture. The glandular mass is divided into two portions. Their appearance resembles more that of the same glands in the bird named ardea argala, than of any quadruped. The internal surface of this portion of the stomach is smooth but not cuticular; the coats are thick near the cardia, but thin towards the pyloric portion. The communication between this and the pyloric portion is by a round aperture, three fourths of an inch in diameter, similar to what is met with between the different cavities of the stomach in the whale tribe. Immediately beyond this orifice there are two openings from the pyloric portion, one from the posterior side into a cul-de-sac six inches long, and one from the anterior only three inches in length. This portion is rather shorter than the cardiac, is thinner in its coats, has a smooth internal surface, and bends a little upon itself before it terminates in the pylorus, which is marked by a welt, or valve.† These two appendages to the pyloric portion, differ from those in the hippopotamus and the pecari, in being smaller and projecting farther, as

* Plate XXIV. † Plate XXV.

well as not belonging to the cardiac portion, as in these animals. All these cavities, including the appendages, were distended with fuci in a macerated state, undergoing trituration.

This complex stomach, belonging to an animal whose food is nearly the same as that of the hippopotamus, makes it very desirable that the internal cavities of the stomach of that animal should be examined and described. This, I believe, has never yet been done; and, whenever an opportunity offers of sending the stomach home preserved in spirit, we trust it will not be lost. Such an examination would probably put us in possession of all the peculiarities in the structure of the organs of digestion, that are met with in nature, for digesting vegetable substances, as well those that grow upon land, as those that grow at the bottom of the sea, or of fresh water rivers.

The duodenum receives the ducts of the liver and pancreas about four inches from its origin at the pylorus. The coats are strong, the internal surface is honey-combed, having longitudinal ridges, and smaller ones in a transverse direction. The jejunum has, on that side which is attached to the mesentery, a row of orifices of glands not in one line, but in a regular zig-zag.

These were very distinct in a small dugong, but could not be seen in a large one. Similar orifices are met with in the colon of the ornithorhyncus paradoxus, ranged in ten separate dotted lines. These orifices extend to the cæcum. The mesenteric glands are large, flat, oval, and thinly scattered.

The cæcum is four times the size of the ilium, conical in its shape, and thick in its coats.

The colon has small lacunæ over its whole surface.

The whole intestinal canal is fourteen times the length of the animal, of which the small make five, the large nine.

There are no valvulæ conniventes in any part of the intestines.

In the only specimen of the manatee that has come under my examination, many of the parts were so much injured as not to admit of examination, this was the case with the tongue and the upper part of the œsophagus. The stomach in all essentials is the same as in the dugong, but still in many lesser circumstances deviates from it; the glandular substance in the cardiac portion is more massy and pyramidal; is separated from the general cavity by a contraction of the coats; the processes close within the pyloric portion are shorter, wider, and broader, that on the under side most capacious.*

There are no valvulæ conniventes in any part of the canal. The cæcum is almost globular, in that respect very unlike that of the dugong.†

On the Stomach of the two-horned Rhinoceros, from Sumatra.

Having received from Sumatra the stomach of the two-horned rhinoceros of that Island, I wish to remark, that it is unlike that from Africa; which has a complete villous internal surface, while this has a cuticular portion as in the

* Plate XXVI. † Plate XXVII.

horse, and a bott of the same species as that found in the stomachs of horses in England*, was attached to the cuticular portion.

On the Nests of the Java Swallow.

Previous to any observations on the human stomach, I shall give an account of the glands from the secretion of which the nests of the Java swallow are formed, as it was an examination of these glands, that led me to reconsider the internal membrane of the human stomach and to ascertain many facts which were till now unknown.

The nests of a particular species of swallow, which is principally met with in the Island of Java, have from time immemorial, formed an article of trade with China, where they are purchased at a high price by that voluptuous people, it being believed, that the materials of which the nests are composed, are possessed of an aphrodisiac virtue in an eminent degree. They have been occasionally brought into this country, and are preserved in collections of natural history, as curiosities. In what manner the bird procures the materials out of which the nest is made, has till now remained unknown; a thousand conjectures have, however, been formed upon this subject. It was supposed by some, to be a gluten collected from the mollusca picked up from the surface of the sea. By others, a substance extracted from certain fuci found on the sea-shore. By others again, a portion of the food in a half digested state regurgitated to be employed for this particular purpose.

* Plate XXVIII.

Sir Stamford Raffles, when he returned from Java, where he resided five years as lieutenant-governor, brought over a number of these nests, and has been kind enough to offer me some of them for the purpose of investigating the nature of the materials of which they are composed; and gave it decidedly as his own opinion, that they are brought up from the stomach, and require at times so great an effort, as to bring up blood, the stain of which is seen on the nest. This account of Sir Stamford Raffles, in the correctness of whose observation I have the greatest confidence, led me to investigate this subject, and to ascertain by examination whether this particular swallow has any *glands* that are peculiar to its œsophagus, or stomach, enabling it to secrete a mucus similar to the substance of which the nest is composed. I at the same time requested my friend, Professor Brande, to analyze one of the nests, and to inform me of its composition.

In examining the gastric glands of the Java swallow, even with the assistance of a common magnifying glass, I saw an obvious difference between the appearance of the orifices by which the secretion is poured into the gizzard, and of those of other birds; but as I had never examined those glands in the common swallow which migrates to this country, it became necessary, before I proceeded farther in the inquiry, to ascertain whether in all the swallow tribe there are similar structures. When this opportunity was afforded me, by the return of the spring, I found that in the common swallow, both male and female, the orifices of the gastric glands differ in nothing from those of birds in general, but that the peculiar structure which I am about to describe is

confined to the Java swallow. This bird, Sir Stamford Raffles informs me, does not migrate, but remains all the year an inhabitant of the caverns in that island. Some of the most extensive caves in which they reside are forty miles from the sea. Those swallows that build their nests near the sea, are observed to fly inland towards extensive swamps, where gnats and other insects are in great abundance.

Those that build in inland caves, are observed to quit the caves in the morning, and generally return in swarms, darkening the air, towards the close of the day; they are, however, going in and out the whole of the day. This bird is double the size of our common swallow.

There are two separate nests, one for the male to lie and rest in, which is oblong and narrow, adapted to his form; the other wider and deeper, to receive the female and the eggs.

As Mr. Bauer has been kind enough to make drawings of the gastric glands in the blackbird, the common swallow, and Java swallow, in which the parts are so much magnified, that the difference in their structure is obvious to the most superficial observer, it is not necessary in this place to enter much into detail respecting them. I shall only observe, that from what is represented in the drawings, it is evident that the gastric glands in the swallow tribe, both those that migrate and those that remain during the whole year in Java, do not afford the same supply of gastric liquor as in other birds, since they have a smaller receptacle belonging to the gland into which the secreted liquor is to be received.

This circumstance confirms the observations that I made, upon a former occasion, respecting the gastric glands of the

cassowary of Java, and of the ostrich; that these glands are largest in those birds that inhabit countries that afford a small supply of nourishment.

The swallow of Java, as well as the cassowary of that island, lives in perpetual plenty; and the swallow that migrates, although it travels from the equator to the pole, only remains in cold countries during the summer season, while the sun fertilizes the earth, and affords a supply of its natural food in the regions of the north.

The only difference between the glands of the migrating swallow and those of the blackbird, is the smallness of the reservoir; the surface of the gullet upon which the external openings of the glands are seen is exactly the same; there is not in the one or the other any apparatus for secreting mucus which is not common to birds in general.

In the Java swallow we have, on the other hand, a structure of a particular nature: there is a membranous tube surrounding the duct of each of the gastric glands, which, after projecting into the gullet for a little way, splits into separate portions, like the petals of a flower. For what purpose so extraordinary an apparatus could be provided, would probably have puzzled the weak intellects of human beings, and many wild theories might have been formed respecting it, had not the animal matter of which the bird's nest is composed, and the accurate observation of Sir Stamford Raffles, who had no doubt that the materials of the nest were produced from the gullet, led to the discovery of its use.*

* Plate XXIX.

That the mucus, of which the nest is composed, is secreted from the surface of these membranous tubes, there is no more doubt, than that the gastric juice is secreted from the glands whose ducts these tubes surround; and this confirms an opinion which I have adopted for many years, that membranes on which no glandular structure could be seen were capable of secreting mucus; and now that we find those membranes, where their surfaces are so much magnified, exhibit no glandular structure, we may, without the chance of more accurate observers refuting us, be satisfied that no such structure exists.

There are, perhaps, no more curious provisions given to animals by their Creator, than those which are to be employed for the preservation of their young, while it yet remains in the egg; but as many of these belong to the organs of generation themselves, or arise from secretions produced by glands immediately connected with them, they pass unnoticed, the mind being lost in the contemplation of so wonderful a contrivance as generation itself.

The present provision for forming a nest out of its own secretions, in an animal of so high an order as the class Aves, strikes us with astonishment, since birds in all other countries find substances of different kinds which answer that purpose, and makes it evident that this particular bird, at the time of its first creation, was intended to be the inhabitant of the caverns of Java, where nothing is met with, out of which a nest could be constructed; as the camel is adapted to the sandy deserts of which it is the natural inhabitant, both by the provision in its stomach for carrying a store of water,

and the form of its hoof, which cannot, like that of other animals, be injured by walking in sand.

The swallows of Java that reside upon the coast, never exhaust their secretions in forming their nests, when they find other materials fitted for that purpose.

The nearest approach to a provision of this kind, is in the insect tribe; the bee secreting the wax out of which it forms its comb, both for the nest of its young, and a reservoir to contain supplies of nourishment.

The nest appears to consist of a substance having properties intermediate between gelatine and albumen. It resists for a considerable time the action of warm water, but after some hours enlarges and softens; upon drying, it again resumes its former appearance and properties, becoming somewhat more brittle than before, probably in consequence of having lost a very small portion of gelatine, which delicate tests discover in the water.

In the diluted acids, this substance dissolves with more ease, than coagulated albumen; in the concentrated acids, its properties are nearly the same as those of coagulated white of egg.

With the caustic and subcarbonated fixed alcalies, it forms saponaceous compounds, which are decomposed by the acids with the same appearances as other albuminous soaps. It readily dissolves in liquid ammonia, and in the solution of subcarbonate of ammonia, circumstances in which it differs from albumen.

When submitted to destructive distillation, a relatively small portion of ammonia is formed, and the remaining coal

is easy in cineration, circumstances which likewise point out a distinction between this substance and albumen.

The Gastric Glands of the Human Stomach.

The magnified drawings of the gastric glands of the Java swallow, led me to request that Mr. Bauer would make similar representations of the glands of the lower part of the human œsophagus, and of the surface of the internal membrane of the stomach and duodenum.

The stomach employed for this purpose was under the most favourable circumstances, as the patient had died of an apoplexy, having no other bodily complaint.

The glands situated in the lining of the lower part of the œsophagus, in the microscope, have the appearance of infundibular cells, whose depth does not exceed the thickness of the membrane. This structure, however different from the gastric glands of birds, is a nearer approach to it, than is to be met with on any part of the internal surface of the stomach or duodenum; it also resembles them in the secretion it produces coagulating milk, and none of the inspissated juices met with in these cavities affect milk in the same way.* From these facts there can no longer be any doubt entertained, that the gastric glands have the same situation respecting the cavity of the stomach as in birds.

In my former investigation, the analogy of the bird would have led me to the same conclusion, had not the gastric glands of the beaver, which are more distinct than in any other quadruped I had then seen, been a stumbling block

* Plate XXX. XXXI.

in my way; but now, the situation of these glands in the beaver and woombat, must be considered as an exception to the general rule, the necessary complexity of their structure making them too large to admit of their being conveniently placed, as is usual, in the œsophagus.

The structure upon the upper arch of the stomach, which, when magnified by a common lens, had the appearance of glands, is shown by Mr. Bauer to be made up of cells in the form of a honey-comb, the sides of which are not formed by doublings of the membrane, for no stretching of the cells alters the form of their orifices, but are regular partitions constructed between the cells. This honeycomb structure consists of cells of the greatest depth in this particular situation, but it is met with over the whole surface of the cardiac portion of the stomach, only the appearance is so faint as to require a great magnifying power to render it visible. In the pyloric portion the cells, in general, have the same appearance, but there are small clusters, the sides of which rise above the surface, giving the appearance of foliated membranes. In the duodenum this takes place in a greater degree, and the loose edges of these membranes when entangled in the mucus that covers them, put on an appearance of rounded globular bodies, but these admitted of being expanded so as to explain the deception.

The description which I have given of the internal membrane of the stomach, proves how nearly my late ingenious friend Dr. George Fordyce, who examined its surface with very inferior means to those employed upon the present occasion, had approached the truth, when he declared it to be composed of cellular membrane.

I have shown, upon more occasions than one, that the gastric glands are both largest and most numerous in those animals destined to inhabit the least fertile regions of the earth, and are smallest. as well as fewest, where the supply of food is most abundant, to prevent the body being injured by the effects of over-feeding. If this arrangement was necessary in animals, it became still more so in man, whose means of procuring and preparing food for himself so much exceed those of all other animals, and who is, contrary to his reason, too readily disposed to carry the indulgences of the table to excess. In him the gastric glands, as it was natural to expect, are so small as to require the aid of Mr. Bauer's microscope, to prove that they belong to the same series of structures as the gastric glands of the ostrich, which admit of being minutely examined by the naked eye.

Much is still wanting to enable us to understand the process of digestion; it is, however, no small step in this investigation, that a more correct knowledge of the structure of the cavities in which it takes place, has been acquired; from which we learn that there are three different kinds of organization employed in adding to the food three different ingredients, which are requisite for its conversion into a material that can be assimilated with living animal matter, and be employed in carrying on the functions of life, also supplying the waste which is constantly taking place. The most important of these is evidently the gastric glands; next in order may be considered the honeycomb structure; and least so, although by no means unnecessary, the foliated membranes, which we know, from what takes place in the Java swallow, form the mucus that is mixed with the other ingredients.

That the stomach is occasionally met with after death divided into two portions by a muscular contraction, I have shown in my former lecture on this subject, in Vol. I.; and I have there given it as my opinion, that this takes place while the process of digestion is going on.

This opinion may, in the minds of many physiologists, require some stronger proofs than I have been able to give; but this, like many other muscular contractions which take place during life, is so often removed in the very act of dying, as rarely (and in some of them never) to be seen after death. We are, therefore, indebted to the effect of disease sometimes rendering them permanent, for any knowledge we have of their existence.

In this way, strictures in the œsophagus, just where the fauces terminate, and the œsophagus begins, being of frequent occurrence, and, upon examination of the parts after death, found to have taken place unconnected with any disease in the surrounding parts, teaches us, that this part has an involuntary contraction when any irritating matter is applied; and thus forms a guard to prevent substances that would prove hurtful to the stomach from being swallowed.

Strictures in the urethra immediately behind the cavity of the bulb, being met with under the same circumstances after the use of irritating injections into the canal, and various other causes of irritation, is the only evidence we had of this part having a power of involuntary contraction, till the late Mr. Wilson discovered the form of the muscle which now should bear his name, employed to prevent any part of the semen from being forced backwards into the bladder.

Through the kindness of Mr. Carpue, I am now enabled to produce a specimen of permanent contraction in the stomach; and if I had not observed such a contraction before, this specimen would have led, as in other cases just mentioned, to the discovery of the stomach in some of its natural functions, having this kind of action take place in it. It occurred in the body of a woman, and was probably the cause of her death, as no other appearance of disease was met with: the body was exceedingly emaciated, but there was no opportunity of acquiring any information of the symptoms under which she laboured when alive.*

As in this instance the stomach could be distended freely without any risk of the contraction giving way, the line of partition between the cardiac and pyloric portions is exactly defined, and shown not to be the casual contraction of a few of the transverse muscular fibres, which might have happened equally to any of the others, but the contraction of a part that had always been liable to it, and which was to answer some purpose in the performance of the functions of that viscus.

On the Lymphatics of the Stomach carrying Fluids into the Vas Breve of the Splenic Vein.

The discovery of valvular vessels in the brain, acting as absorbents in that organ, immediately led me to suspect that there must be a similar provision for carrying off the fluids taken into the stomach, whenever the quantity or quality interfered with the process of digestion. To do this

* Plate XXXII.

by the route of the thoracic duct, was not only too circuitous to correspond with the general simplicity of the operations of nature, but was mixing these heterogenous liquids in too crude a state with the general circulation of the blood. That there was some unusual mode of conveying fluids from the stomach to the urinary bladder, I have upon a former occasion established, since they arrived there when both the pylorus and thoracic duct were tied up, and the spleen was removed out of the body; but till the fact of valvular vessels supplying the office of absorbents was ascertained, any opinion respecting the route of fluids from the stomach must continue to be entirely hypothetical.

Upon the present occasion, Mr. Bauer's microscopical observations have not only enabled me to demonstrate vessels so constructed in the coats of the stomach, but to give abundant collateral evidence of their acting as absorbents, even more than can be produced respecting those of the brain.

It immediately suggested itself to me, that this was the probable use of the branches of the vas breve, the presence of which upon the coats of the stomach, so well supplied from other trunks, is not easily accounted for upon any other principle.

In the first instance, with the assistance of Mr. Clift, I injected the splenic artery, and requested Mr. Bauer to ascertain whether any minute branches met with upon the great curvature of the stomach, in a contrary direction to those injected arteries, had valves. Such vessels were found, and quite empty. They had valves very distinctly marked; he showed them to me, so as perfectlv to satisfy me of the fact.

Having got thus far, I requested the assistance of Mr. Chevalier, House Surgeon to St. George's Hospital, who has given, at different times, considerable attention to preparing the stomach and spleen for Mr. Bauer's observations; which he has been better able to do, from being more in the habit of injecting the blood-vessels, than students in surgery generally are; Mr. Clift's important occupations in this college depriving me of his valuable assistance. I requested Mr. Chevalier to inject, as minutely as possible, the branches of the splenic artery and vein going to the stomach. In one instance, he succeeded so well that the arteries were filled to the most minute branches; and some of the injection had passed into the stomach, without any apparent rupture of the vessel. No part of this coloured injection had got into the veins, which in other parts of the circulation generally happens. Between the villi and the muscular coats of the stomach there is a very fine elastic cellular membrane: it admits of being drawn out to more than three times its natural thickness; and it was by doing so, Mr. Bauer caused these smaller arteries to be exposed, and, along with them, small valvular vessels, quite empty: the valves were very numerous, and nearly at equal distances.* In tracing these towards the cavity, they became indistinct just as they entered the villi. His representation of the valves in these vessels, as well as that of the valves of the vessels in the brain, may be considered as demonstrations of the fact; and still more valuable than preparations, since the appearance can be better preserved.

* Plate XXXIII.

To show the course of the absorbed fluids, as well as to give a clear idea of every thing connected with so *important* a discovery, a drawing of the spleen, the vas breve, and cardiac portion of the stomach, is annexed; and as the trunk of the splenic vein forms one of the trunks of the vena portæ, the liquids are directly carried to the liver, forming a part of the materials employed in producing the bile; the remainder only returning by the vena cava to the heart.

This additional quantity of liquids passing along the splenic vein, accounts for its being five times the size of the artery, as well as for the blood in that vein having a greater proportion of serum than the blood in any other, which has been long asserted, and which I found by actual experiment to be the case; but being unable to account for it, as I can now, I was unwilling to bring a fact forward which I could not explain.*

The formation of gall-stones, in which resin is a principal ingredient, can now be explained in a satisfactory manner; since Professor Brande finds that rhubarb contains resin. Unfortunately for theoretical medical reasoning, rhubarb has been considered as an excellent medicine in hepatic complaints.

On the Spleen.

I first engaged in the herculean labour of investigating the structure and uses of the spleen, in the year 1807. In that attempt I ascertained that the variation which takes place in the size of this organ depended upon the fulness or

* Plate XXXIV.

emptiness of the stomach. My further enquiries proved unsatisfactory.

In the year 1810, I again took up the same subject; and corrected some of my former errors by completely proving that there is a channel by which fluids pass from the great end of the stomach into the circulation, although not through the medium of the spleen, without passing along the thoracic duct.

I have now a third time resumed the enquiry; and, with Mr. Bauer's assistance, my labours have been crowned with success. That they were not so before, arose principally from my ignorance of the component parts of the blood; without a knowledge of which, the structure of this organ must have continued to baffle all enquiry.

This organ, like the Proteus of old, undergoes so many changes, and these so unlike one another, that it required, as it did with that imaginary deity, something more than common to bring him back to his proper form, in which he was compelled to speak the truth. Thus it has hitherto been with the spleen. In no two examinations was its appearance the same: it required the microscope of a Bauer, like the talisman of the gods of yore, to fix it to a state that admitted of explanation. The microscope having, as has been already explained to my audience, analyzed the blood, and developed its component parts, has now enabled me to explain the original conformation of the spleen; to follow all the apparent changes its structure undergoes; and to resolve them into the different ingredients that were deposited in its substance, and the various proportions in which these were met with under different circumstances.

Having got thus far in the elucidation of a general principle, I consider myself enabled to explain the structure of the spleen. I am, however, at a loss whether I should, in my explanation, begin with the synthetic or analytic mode of demonstrating this structure.

If I am to take the analytic, which is undoubtedly the most appropriate for the structures of animal bodies that come under our observation in their full and complete form, I shall previously describe the appearance of this organ in its full and empty state.

All that is to be derived from such an explanation of these appearances is as follows:—

That when the spleen is in its largest state of increase, upon the surface the appearance of lymphatics in great abundance is conspicuous: these ultimately terminate in a lymphatic vessel, nearly of the size of a crow's quill, which communicates with the receptaculum chyli.

Upon cutting into, or making a section of its substance, the general mass has a red colour, extremely moist, with whitish bands crossing the mass in all directions. This mass or section is studded over with little spherules, perfectly distinct from the immediately surrounding parts, which, on a superficial view, look like glands: these, when the veins are injected, appear to be surrounded by plexuses of veins; and when, instead of the veins, the arteries are injected, they appear equally surrounded with plexuses of arteries; but, by a strange inexplicable circumstance, when once the veins of the spleen have been well injected, there is no chance of injecting the arteries with an equal degree of minuteness.

This for a long time appeared very extraordinary, but the fact was undeniable; the cause, however, was at last explained. The arterial and venal trunks, which go to and come from the spleen, are in pairs, and are enclosed in one common strong elastic theca; so that when once the venal trunk is distended by injection, there is not space in the theca for the arterial trunk being distended in the same degree.

This circumstance, which till now has not, I believe, been attended to, has a great deal to do with the functions of the spleen.*

Having described the appearance of the spleen in its full state, I shall now do the same in its empty state. In this it is reduced to half its size; all the appearance of glands or spherules is entirely gone; and a section of this organ displays one uniform red surface, with an appearance of white, strong, elastic bands, holding the sides of the covering of the viscus or organ together. The difference of the appearance of the internal structure of this organ, it has been already stated, depends upon the stomach having been supplied with or deprived of nourishment.

From these appearances, which are within the reach of every observer, the spleen has hitherto been considered to consist of a net-work of ligamentous texture, with numerous arteries and venal branches, having cells containing small corpuscles or glands; but this appearance vanishes when the parts are more minutely examined, which was done in the following series of experiments.

* Plate XXXV.

August 23*d.* 1820.—A large spleen, taken from a healthy man, twenty-eight years of age, was cut into eight transverse slices of equal thickness: four of these were put into one dish filled with distilled water, and four into another: although the surfaces were extremely red, yet upon their immersion they did not part with any of their colour, the water remaining pure, the cells in these sections, when examined under water, by a common lens, were beautifully distinct, and had an uniformity in their appearance rarely met with; they were all full upon the upper surface, but on examining what had been the under surface, they were all empty; and when the slices were turned a second time, those on what had originally been the upper surface were also found empty; a deposit was seen with the naked eye on the bottom of the dish, which, however, during the whole of this examination, had not received the slightest tinge of red colour; the water remaining equally clear as it was before the sections of spleen were immersed in it. When the deposit was examined in the microscope it consisted entirely of lymph globules, without any connection among themselves.

24*th.*—At the same hour the sections were examined, round each slice there was a zone of colouring matter in the form of a circle, but not in immediate contact; it was so defined, that it appeared to be red serum separated from the section, not the colouring matter discharged into the water; the surface of the section was less florid. On examining the cells with a lens, those on the upper surface appeared to be hollow, but those on the under were full of

a semi-transparent mucus, and several had a film of it spread over the orifice.

All the sections were changed into clean vessels with fresh distilled water.

25th. — Both the upper and under surfaces of all the sections had become obscure by a film of a floculent mucus which covered the orifices of the cells, but when this was washed away, the figure of the orifices was equally distinct as before, but they were no longer empty; there was a zone round each, containing a larger proportion of colouring matter.

26th. — The cells on both surfaces of the sections were not only filled with the transparent mucus, swelled out by the absorption of the surrounding water, but they rose above the level of the general surface; this mucus had a lighter tint than the other parts which were of a deeper red, looking exactly like specimens of plum-pudding stone.

27th. — The appearance of the sections had undergone little perceptible change.

28th. — The surface or orifices of the cells had become flat; the discharge of colouring matter into the water was considerable.

29th. — The cells were more flattened, and a light coloured speck was seen in the centre of each.

30th. — The water was still tinged with the colouring matter.

31st. — The sections were so much covered with a slimy mucus as to have become slippery, and circular black spots were seen in different places; some of these corresponded to

the exact orifice of the cells, others seemed to be upon the orifices of divided arteries.

September 1*st.* — The black spots had become more numerous. On the surface of the slices much colouring matter, but no more slime had dissolved in the water; the black appearance arose from a change having taken place in the colouring matter that rested upon the surface of the section.

2*d.* — The black had now extended over a portion of the surface; there was also an increase of mucus on the surface.

4*th.* — The colouring matter was almost entirely washed out; the cells were more distinct, not being nearly full; a greater portion of the surface had acquired a black colour; both the upper and under surfaces were equally slimy.

5*th.* — The mucus almost all washed out, and the surface more extensively of a black colour.

6*th.* — Putrefaction had begun; the cells were quite empty, and as distinct as when the sections were first immersed in the distilled water, the black still extending itself.

8*th.* — The upper surface of a black colour, and without any appearance of cells, although they were tolerably distinct on the under, which was not black in any great degree.

12*th.* — All the parts composing the section, except the trunks and ramifications of blood-vessels, had entirely disappeared.

August 29*th.* — The spleen of a woman, who had taken little or no food for several days, hardly more than one third of the size of the other, was cut into transverse sections, but did not exhibit any appearance of cells; by

the same mode of treatment, it was gradually reduced to a tissue of blood-vessels.

From these experiments, the spleen when empty, consists of arteries and veins; and these having no cellular membrane in their interstices, the space is filled up by coloured serum.

The venal trunks in the concave part of the spleen, when slit open are found to have lateral orifices, through which their contents pass out when the arterial trunks are sufficiently distended to compress the venal ones in the theca, as they pass out to join the splenic vein.

In the empty state of the spleen, which happens after fasting, it appears to have an elastic strong external covering, the sides of which are supported by bands; these, when examined, prove to be strong arterial branches, firmly attached to the external coat, having corresponding veins and lymphatic vessels in the interstices; there is no cellular membrane, only a coloured serum, in which neither lymph globules nor blood globules are met with.

The spleen, in the full state of the stomach, becomes turgid, and the corpuscles are distinctly seen; they are formed in the following manner:—the smaller arteries pour out lymph globules and the transparent elastic mucus, soluble in water, without any of the other component parts of the blood; the lymph globules, according to the general law of fluids, take a globular form, and the mucus coagulating forms surrounding cells in which they lie loose, and, whenever the cells are opened and turned upside down in water, fall out.

That these cells are formed from the contents of the smaller arteries extravasated, is proved by an examination of

the spleen of a child, five years old, in which the arteries alone had been minutely injected; a section was made of it, in which the smaller branches were distinctly seen terminating in spherical nodules of injection, forming an exact representation of the above-mentioned cells, filled with lymph globules.

It is to be remarked that no red globules are met with in the spleen, except what are circulating in the arteries and veins; the spleen, therefore, is a reservoir or depot in which is laid up a supply of colouring matter, lymph globules, and elastic transparent gelatinous substance, soluble in water, which are carried into the thoracic duct by means of the lymphatic vessels when the circulating blood requires them.*

The main object of comparative anatomy is to make us more perfectly acquainted with the structure of our own body; not as a matter of simple curiosity, nor altogether with the view of comprehending to a greater extent than can be otherwise done, the power, the wisdom, and the excellence of our Almighty Creator: that, indeed, alone, would amply repay the labour of those who engage in such investigations; but there is another, which makes it our bounden professional duty to carry on such pursuits; since by these means, and these only, we can acquire the power of affording substantial relief to those of our fellow creatures labouring under disease, or the effects of accidental violence.

I have thus prefaced the observations I am about to make, that they may not be considered as misplaced.

* Plates XXXVI. XXXVII. XXXVIII.

In what has been said of the brain and of the nerves, one of the materials is a transparent, elastic, gelatinous substance, soluble in water; and this substance has also been proved to constitute a part of the blood. This is also stated to be one of those ingredients contained and deposited in the spleen, and can be separated from it by a succession of applications of distilled water, in which it readily dissolves, and becomes invisible.

When slices of the same spleen were put into pump-water, instead of the water remaining transparent, as the distilled water did, a thick viscid scum rose to the top, which every day became thicker, and in greater abundance. When this effect was considered, it appeared to have arisen from the transparent jelly, in the act of dissolving, taking up all the impurities in the water, forming with them a compound, rendered visible by the impurities with which it is loaded.

From what happened to the jelly out of the body, there can be no doubt that it is kept in solution in the serum of the blood, when not employed in uniting the colouring matter to the globules, forming them into red globules.

This circumstance shows of how much consequence to a healthy state of the body it must be, to have the watery part of the serum in a pure state; since, when it is otherwise, it vitiates this mucus, by uniting with it, and renders the whole mass of blood incapable of performing its healthy functions, particularly, in affording the necessary repairs for the waste of the brain and nerves.

Under this idea, I have sent a considerable number of patients, more particularly young boys and girls, with diseased joints, glands that were enlarged, and sores that did not heal,

to Malvern, with directions to do nothing but drink the water, and apply it to the parts affected. This water, Professor Brande many years ago analysed at my desire, and found its purity was its only virtue, at least no other could be detected. It is remarkable for one peculiarity, that all the tea-kettles which are carried there from London, encrusted in different degrees on their inner surface, in a short time have the crust removed, the impurities parting from the kettle, and dissolving in the water, for which there is the greatest attraction.

That these waters do perform cures in many cases, which may be termed obstructions in the smaller vessels of joints, and glands, is most true; and the beneficial effect is almost immediate, being witnessed in two or three days: Is it, then, unreasonable to conclude that its salutary effects arise from its supplying a purer water to the serum, than that which had been previously carried into the blood-vessels?

LECTURE VI.

On the Structure of the Heart in different Animals.

[Continued from the Third Lecture in the First Volume.]

I shall now endeavour to show from what part of the blood the ultimate fibres of muscles are formed, and afterwards attempt to explain the varieties met with in the hearts of different animals.

That a red colour is not necessary to constitute a muscular fibre has been already shown, and is universally admitted, but as the muscles are formed out of the blood, all of them which are to exert much power, must have a ready supply to repair the waste which takes place, and therefore all strong muscles are red from the great quantity of red blood with which they are furnished.

Mr. Bauer found, in his investigation of the blood, as has been already explained, that the red globules, when deprived of their colouring matter, which under a variety of circumstances is found to take place, they are seen floating in the serum, and have what they did not possess before, a

disposition to coalesce and unite together: their mode of union varies under different circumstances; the surrounding serum being deeply tinged with colouring matter.

In one place the globules were seen brought into one line; in another, four globules were found connected with lateral indentations at the points of union.*

This renders it probable that the red globules, deprived of the colouring matter, are the materials contained in the blood from which the muscular fibres are principally formed; and, if this were true, the smallest possible reduction of the fasciculi to an integral fibre would bring it to the size of the diameter of a red globule deprived of its colouring matter. After several failures, Mr. Bauer succeeded in reducing the macerated muscle of a roasted chicken's thigh to a fibre similar in dimensions with such globule: when measured on the micrometer, there were similar indentations, but they could not be distinguished beyond four.

In the prosecution of this investigation, Mr. Bauer found that muscular fibres, after having undergone the process of roasting and boiling, and then macerated in water for a week, changing the water daily, the fibres were more readily separated, and he had no difficulty in procuring them of the dimensions above described.

This he did from the coats of the human stomach, the muscles of the thigh of the sheep and rabbit, and also of the salmon.

When the fibres are macerated for a longer time, they are readily broken down into a mass of globules, of the size of red globules deprived of colour.

* Plate I. fig. 4, 5, 6.

The accuracy of this statement may be depended upon: how far it will account for all the combinations that are produced in the structure of muscles, must require much future investigation to determine.

I may be allowed to assume that we have now arrived at the ultimate fibre of which a muscle is formed; and this I do without fear of proof being brought to the contrary.

Having done this, I wished to ascertain whether the ultimate fibres of any muscle are ever extended to considerable length, and if they are, I thought the heart the muscle of all others in which that was likely to be met with; I therefore placed that important organ, with this view, under Mr. Bauer's observation.

In examining the larger fasciculi of fibres of the human heart, I found that they could be dissected distinctly the whole extent of the muscle; but when Mr. Bauer attempted to reduce them to their ultimate fibre, they broke off at short lengths; becoming shorter and shorter as their thickness diminished. So that one general principle appears to pervade the structure of all muscles.

There is no series of structures in the human body, or in that of animals, so beautiful as the complication of the mechanism of muscles to increase the power, and diminish the quantity, of contraction, according to the necessity; so there is no gradation of structures so admirably illustrative of the wisdom of the all-powerful Creator, as what is met with in the hearts of different animals.

Although our knowledge on this subject is not complete, yet it is sufficiently extensive to enable me to lay before you the general principle which is adopted.

In animals that have no vascular system, consisting solely of a membranous bag, there is much reason to believe no waste of materials takes place, while in a quiescent state; indeed the facts which Mr. Bauer has published in the Philosophical Transactions, respecting the worms that form the disease in wheat called by farmers the Purples, of which I took notice in the Eighth Lecture of the First Volume, upon the Digestive Organs of Worms and Insects, completely establishes this fact. I was less acquainted with this subject at that time than I am at present. I mentioned that it had been first noticed by an Italian; I now find Mr. Bauer, in enquiring, at the desire of Sir Joseph Banks, into the diseases of wheat in 1807, found this worm, and made drawings of it. He has preserved some of them ever since, in a dried state, and has found, that although they have been kept so for six years, and even longer, that when moisture is applied to them, and they are placed in the field of the microscope, they revive in five or six hours, and move with great agility. I have myself witnessed this very extraordinary phenomenon, after being dried for six years; to me the most wonderful in nature respecting muscular motion.

The animals next in order to these worms are other genera of vermes, in which there is a circulation, but no heart: of this kind are all caterpillars and insects. In them the blood does not circulate, and probably remains at rest at those times in which the animal is in a quiescent state; but during the period of locomotion, or when feeding, or using other muscular exertion, the blood undulates from one end to the other of a large tube situated upon the back; at such times

supplying the different organs, and becomes aerated by the air-vessels which pervade every part of the body.

Were animals classed according to the different modes of aerating the blood, one great class might be formed of those animals, in which the air circulates through the body, and the blood is confined to a reservoir; another, when the blood circulates through the body, and the air is only applied to a particular portion of it.

The heart will therefore be found to be of less importance than it has been generally considered, and only to be an organ met with in some of the higher orders of animals.

When we consider the aeration of the blood in insects, it must be greater than in other animals; and there is this curious circumstance arising out of their bodies being so abundantly supplied with air,—as soon as the cold is too great for their exerting muscular power, the spiracula becomes closed, and the animal remains in a torpid state: by any increase of the warmth of the atmosphere, the air retained in the tubes is rarified, the external orifices of the spiracula are forced open, and the functions of life are again carried on.

This fact is not to be doubted, since we see the same thing take place in the vermes when they shut up for the winter. The garden-snail, as soon as the cold weather sets in, fixes itself upon any hard substance by throwing out a slime which cements the open edge of the shell to the surface, and the snail remains there during the winter-months; all the organs of the body being in a state of rest.

When warmth and moisture are applied, the membranous film falls off; a globule of air that remained in the cavity of

the lungs becomes rarified, and forces its way out, and admits of fresh air being applied to these organs.

In animals in which the circulation of the blood is carried on by means of a heart, the blood is aerated in very different proportions.

The only reason for having the whole mass aerated, is to admit of greater muscular exertion being used without producing fatigue; and as this state of aeration requires more frequent supplies from the atmosphere, an inconvenience is produced in those animals that live in water, and breathe air; on which account it is dispensed with, to admit the animal to remain a longer time under water, as in the sea-otter. In that animal, the foramen ovale between the auricles remains open.

In describing the different modes of circulating and aerating the blood that have come under my observation, I shall begin with the most simple.

The aphrodita aculeata has, properly speaking, no blood-vessels; the water is received, by thirty-two lateral openings between the feet, into the cavity under the muscles of the back, and there applied to the surfaces of the projecting cells; of which there are two rows, fifteen in each; through these the air in the water is communicated to the cæca contained in them, which I consider to be the respiratory organs.

In the leech there is no heart, but a large vessel upon each side of the animal; and the water is received through openings in the belly, into the cells or respiratory organs, and passes out through the same.*

* Plate XXXIX.

In the earth-worm there is an artery that passes up the back, and a corresponding vein passing down from the head upon the middle of the belly: near the head, there are five pair of lateral canals that swell out beyond the size of the large vein; these communicate freely between the artery and vein; so that they become reservoirs of blood to supply the vessels of the head when wanted to bore through the earth; and the action of the muscles so employed will by their situation accelerate the circulation. The œsophagus, lying in the centre of these reservoirs, will, by the action of its coats while the animal is eating, have an influence on the circulation. The blood is aerated by lateral cells in the same manner as in the leech.

In the *muscle*, the gut passes through the heart which is an oval bag, having no auricle, unless the two large veins are called such; the coats of the ventricle are very thin, but the action of the intestine makes up for this deficiency.

In the earth-worm, the circulation is properly in a circle without beginning or ending. One vessel runs upwards to the head, along the back, communicating with the lateral reservoirs, but still a continued tube goes on. It is the same with the vein or opposite vessel that runs down to the tail, and the branches that go from the artery to the lateral cells have corresponding branches returning the blood to the great vein. This may be considered as one mode of circulation peculiar to this tribe; and it is admirably contrived that the blood may be accelerated in its motion by the muscular action of the body of the animal, without any increase of action in the arterial system.

The aeration of the blood in this mode of circulation is imperfect; only one portion being aerated, and mixed with the rest, in which no such changes have been produced.

In the lumbricus marinus, although the principle of the circulation is the same, there are many strongly marked differences in the mode of carrying it into effect.

There is, as in the terrestris, one trunk behind, going from the tail to the head, and one from the head to the tail on the belly, completing the circle; but in this animal there are external gills, which remain protruded while the animal is in water, and the blood has such a velocity in their vessels, that they may be considered as so many small ventricles*; this, it will be seen hereafter, is an approach to the construction of the gills of the sepia. In this circulation there are two regularly formed auricles, supplied by lateral veins from the viscera attached to the sides of the great artery; so as to increase the supply of the blood, and afford quantity as well as velocity: while it gives off branches to the gills, the main trunk pursues its course, supplying the body. In this animal, it is only a portion of the blood which is aerated; and, from the structure of the gills, that must be in a much greater degree than in the lumbricus terrestris.

The animal whose heart is nearest in structure to those which I have described is the oyster; in which the whole blood is aerated in passing through the gills, before it is received into the auricle. In this animal, the auricle and ventricle are very thin in their coats; so much so as to make them unequal to apply force to the blood; but the ventricle

* Plate XL.

is laterally connected to the great muscle, whose action will accelerate the circulation.

Immediately above the oyster and most of the other vermes, although the circulation is formed upon the same principle, are the teredines; the most common species of which is the toredo navalis; but as my friend, Mr. Griffiths, brought over from Sumatra the shells of the toredo gigantea, an animal the existence of which, had I not been in possession of the shells, I should not have ventured to assert, for fear of having my credulity called into question. The following is his account of them:—

A short time after a violent earthquake had occurred in the island of Sumatra in the year 1797, these uncommon productions of nature were discovered. The violence of the concussion was more particularly confined to the part of the island situated on the sea-coast, between two degrees of the equator, north and south, and to the islands adjacent.

These shells were procured in a small sheltered bay, with a muddy bottom, surrounded by coral reefs, on the island of Battoo. Upon the sea receding from the bay, after the inundation, they were seen protruding from a bank of slightly indurated mud; and some broken specimens were brought to Mr. Griffiths, who was so struck with their curious appearance, that he sent a prow and an expert diver to procure some of them. From this man he obtained the following account of their situation and appearance:—

He found the tube-shells in the above-mentioned bay, and in another inlet of the sea, stretching out of rather hard mud, mixed with small stones and sand, from one to three fathom under water: they were separate from each other.

the animal threw out tentacula from two small apertures at the apex of the shell resembling the small actinea adhering to the rocks in the neighbourhood; that the animal was soft and gelatinous; that they were in considerable number; and upon gently shaking the tube, they were easily taken up: but all of them were brought more or less mutilated, probably shook to pieces, by the earthquake. Mr. Griffith received more than twenty specimens, but not one was complete; although a perfect one might be made by taking different portions of the broken ones. The largest was five feet four inches long, the outside milk-white, and the circumference at the base nine inches, tapering upwards to two and a half inches; the inside had a yellowish tinge: this specimen was nearly perfect, having a small portion of the lower end entire.*

No two were of the same size: the great end was found in some completely closed, and there very thin; the small end is very brittle, and divided by a longitudinal septum, eight or nine inches long, forming two distinct tubes of that length; from these pass out the tentacula; the substance of the shell is composed of layers, having a fibrous and radiated structure; the different stages of its growth is shown by interruptions in the white crust, in a transverse direction, by a sudden increase of thickness; these are at the distance of four or six inches. These shells all differ in thickness, from one eighth to half an inch; some are straight, others crooked; the inner surface is smooth, though in some places there are round, projecting tubercles.

* Plate XLI. XLII.

These shells are the largest tubulas testacea yet discovered. when broken, their crystallization resembles that of stalactite; and they were, when first brought over, mistaken for them.

They are mentioned by Rumphius; but his is a different species.

Having given Mr. Griffith's account of the external appearances of this extraordinary shell, I shall give, from my own observation, an account of the heart and circulation of the blood in the toredo navalis, which has hitherto been very little known. Sellius's account, the author most to be depended upon, is very vague.

I procured a piece of wood from Sheerness, in which many of the teredines navales were alive, and was allowed to examine one of a larger size preserved in the British Museum.

These opportunities, with the able assistance of Mr. Clift, have enabled me to explain the circulation of the blood in this very curious tribe of animals.

*The heart is situated upon the back of the animal, near the head, consisting of two auricles, of a thin, dark-coloured membrane; the auricles open by contracted valvular orifices into two white, strong tubes; these, united, form the ventricle, which terminates in an artery that goes to the boring-shell. The heart is loosely attached; its action is distinctly seen through the external covering, and in some instances continued to act after it was laid bare.

The first contraction is in the two auricles, which are shortened in that action; this enlarges the ventricle before it contracts. The great artery from the ventricle goes directly to the head, and the vessels that supply the auricles

* Plate XLIII.

are seen to come from the gills. The auricles are lined with a black pigment, so that their contents cannot be seen through their coats; and the ventricle, from its thickness, is not transparent; but the muscles of the boring-shells are of a bright red, and all the parts between the heart and head are supplied with red blood.

The structure of the heart is different from that of the lumbricus marinus, and consequently the circulation is by no means similar.

This animal's heart may be said to be the first in this series that is complete, and this the first regular circulation of the blood; every part of which passes through the vessels of the gills, and then through the cavities of the heart. As this animal is to work a machine capable of boring a very hard substance, and to go on working, during the whole of that period of life in which its growth is continued, to make room for the increased bulk; so it requires that the blood be more highly aerated and supplied with greater velocity to these active organs. The heart also, to give it greater advantage in these respects, is placed near to the boring-shells; so that the blood which goes to them is of the brightest colour.

In this circulation, the first action of the heart is to supply the different parts of the body with aerated blood: upon this the activity of the heart is wholly exerted; the blood is returned more slowly through the gills, and remains there a longer time, so as to receive a greater degree of the influence from the air contained in the water.

This I have mentioned to be the principle on which the circulation of many of the vermes is established, and is

exactly the reverse of what takes place in fishes, reptiles, and the higher orders of animals.

The mode in which the breathing organs of the teredines are supplied with water makes it evident, that all sea-worms which have no cavity for the reception of sea-water must have the breathing organs placed externally, as is the case with all those species of actinia met with in the West Indies called animal flowers; and the beautiful membranous expansions they display, resembling the petals of flowers, are in fact the breathing organs, acting at the same time as tentacula.

In the sepia this mode of circulation is rendered more complex; but the same principle is adhered to. In the teredines the water is intimately applied to the gills, from the simplicity of their structure; but in the sepia they are more complex, and require force to apply the water to every part of them, and for this purpose there is a bulb and double valve placed at the root of each gill.

That this circulation may be more clearly understood, I have annexed a drawing of the heart of the sepia officinalis, made in the year 1787, by Mr. Bell, draughtsman to Mr. Hunter. The preparation is in the Collection.*

In the sepia the blood is brought to the gills from all parts of the body by three sets of veins, all branching off from the trunk of the vena cava. The common trunk that goes to each gill is of so large a size, and so thin in its coats, that to prevent the regurgitation of the blood the valve is interposed: the blood having got into the gills, and having pervaded every part of the branchia, it is conveyed by a smaller trunk to the auricle, so that the gills will never be

* Plate XLIV. XLV.

completely emptied; it is then received into the ventricle, and carried by the aorta to the different parts of the body.

Having noticed these peculiarities in the circulation of the blood, and the mode of its aeration in the vermes and different species of sepia, I have to notice that in the lamprey, lampern, the myxene, and an animal nearly allied to it from the South Seas which has never received a specific name, although there are peculiarities in the gills from which these animals must be considered in their aeration inferior to fishes at large, they resemble them in their circulation.

In the lamprey and lampern the water is received by the seven lateral openings on each side of the animal, into the bags that perform the office of gills, and passes out by the same orifices; the form of the cavities being such as to allow the water to go in at one side and out at the other, after having passed over all the projecting parts. A part of the water escapes into the middle tube, and from thence passes out either into the other bags or at the upper end into the œsophagus.*

There is a common opinion that the water is thrown out at the nostril; this, however, is unfounded, as the nostril has no communication with the mouth. The elasticity of the cartilages of the thorax admits of the water being received, and it is expelled by the action of the muscles drawing up the cartilages and pericardium. The animal from the South Seas having no cartilaginous thorax, the bags themselves have an elastic covering, which keeps them open to receive the water, and it is expelled by the action of the external muscles into the œsophagus.

* Plate XLVI.

In the myxene the elasticity of the two tubes, and the bags into which they open, admits of the water being received; and the pressure produced by the action of the external muscles forces it into the œsophagus, from whence it is thrown out by the opening at the lower end of that tube.

Bloch has given a correct account of many parts of the myxene, illustrated by engravings; but there are several errors respecting the mode in which the water passes out. He supposes it to be thrown out at the nostril. He was probably led into this mistake from finding a posterior nostril communicating with the mouth.*

In considering the peculiarities in the circulation of the blood in fishes, I shall make the following observations on the structure of the branchial artery.

The muscular structure of the branchial artery of the dog-fish, and the direction in which that artery leaves the ventricle, are exactly the same as in the squalus maximus, only they are seen upon so small a scale that they do not arrest our attention; but when magnified to the same size which they acquire in this fish, they make a stronger impression upon the mind, and force us irresistibly to enquire after their use.†

The direction of the artery appears to be common to fishes in general, but the muscular structure that is met with in the branchial artery is confined to particular tribes. I find it is common to the sharks, and is met with in the sturgeon.

In the wolf-fish the anarhichas lupus, the muscular structure of the branchial artery is nearly the same; but

* Plate XLVII. † Plate XLIX.

the valves are placed close to the opening of the ventricle, and only two in number.

In the turbot there is no muscular structure in this part; but the coats are extremely elastic, and admit of being very considerably dilated, particularly at its origin, where three valves are placed, and so contrived that the dilatation of the artery makes them shut more closely.

In the lophius piscatorius there is no appearance of muscularity in the coats of the branchial artery, and no lateral valves, as in other fishes; but there is a muscular tube half an inch long, rising from the edge of the opening of the ventricle which projects into the artery.*

These different structures, so unlike one another, and bearing no resemblance to the mechanism in the same parts in quadrupeds, make it probable, that the circulation through the gills is impeded by the external pressure of the water, in different degrees, according to the depth of the fish from the surface; therefore, in those fishes which frequent the great depths, as the squalus in all its tribes, there is a muscular structure in the coats of the branchial artery, which, when the fish is deep in the water, by its contraction diminishes the area of the vessel, and makes the valves perform their office; but when the fish is near the surface, this muscular structure, by its relaxation, renders the area of the artery so wide, that regurgitation of the blood takes place into the ventricles, and prevents the small vessels of the gills from being too much loaded.

That such regurgitation can take place when the muscle is relaxed, is ascertained by the ventricle being readily

* Plate XLVIII.

injected after death with coarse injection from the artery, the valves allowing it to pass.

In fishes that swim deep and do not come to the surface, as the wolf-fish, the regurgitation does not take place into the ventricle; but the relaxation of this muscular portion of the artery allows it to dilate and form a reservoir, and the valves remain closed so as to prevent more blood leaving the ventricle.

In fishes residing at moderate depths, as the turbot, elasticity is employed as a substitute for muscular power, there being less variation. In the lophius piscatorius, which probably never descends into water of great depth, the ventricle is so weak that the supply of the blood to the gills is regulated by the contraction and relaxation of a muscular valve.

As water, according to the degree of pressure upon it, is capable of containing a greater or less quantity of atmospherical air than under ordinary circumstances, such a supersaturated state of the water might compensate, with respect to the respiration of fishes, for the difficulties which occur at great depths of forcing the blood through the vessels of the gills.

I enquired what evidence could be produced of the water at great depths, containing a more than ordinary quantity of of air. My philosophical friends to whom I proposed this question said it was a point that had not been considered. I therefore resolved to put it to the test of experiment; and as I knew there was a well at Mr. Coutts' banking-house in the Strand, which, more than twenty-five years ago, had been sunk four hundred feet below the surface of the Thames,

I made the experiment in this well. A cylindrical vessel, with a valve above and below, was let down to the depth of one hundred and eighty-six feet, which is now the depth of the well: it came up full of clear water, which Professor Brande found contained only the usual proportion of air found in river water.

The mechanism common to most fishes appears to be intended to prevent too great a force being employed at one time in impelling the blood through the gills, which at no time affords much resistance, not even in the sepia.

In the highest class of animals the resistance in the lungs is so great, that a power is required to propel the blood nearly equal to that employed to do so in the circulation through the body; and I shall close this Lecture with an account of the heart of an animal only newly discovered, in which the right ventricle is nearly as large as the left, and unattached to it.*

This is the dugong from the Eastern seas, particularly in the Straits of Malacca.

The manatee, or dugong of the West Indies, is so similar in its general appearance and internal structure, that although the heart has not yet been examined, there can be no doubt of its having the same structure.

As it is the mechanism of the lungs which makes such a power in the right ventricle of the heart necessary, I shall first give the description of them, and afterwards proceed to that of the heart.

The external opening of the nose is that of the whale-tribe in miniature: the os hyoides has a similar form. The

* Plate L.

epiglottis is long and has a ligamentous edge: it stands up in the posterior nostrils, but does not form a tube with the glottis, as in the whale. The glottis, thyroide, cricoide, and arytænoide cartilages resemble those parts in the human body. There are no sacculi laryngæi; but two ligaments pass forwards from the base of the arytænoide cartilages to have an attachment to the concave surface of the thyroide cartilage, forming a rimula glottidis, which can be made wider and narrower, and the ligamentous bands tighter or looser, by the action of the arytænoide muscles. I have dwelt more on the cartilages of the larynx, which are so different from those of the whale, as this animal is said to make a noise like a young child. The trachea is only two inches long before it divides into two, the rings are circular, although they form a spiral.*.

The lungs are one-fourth the length of the animal, exceedingly elastic, the cells very small, as in the whale: those nearest the surface are twice as large as the others, so that they cannot readily empty themselves.

The heart has its ventricles completely detached from each other: when we compare this with the heart of the whale tribe, we find that the right ventricle in the whale is a nearer approach to the left than in the quadruped.

The ventricles in the dugong, although similar in structure, are not exactly of the same size. The left is thickest, and half an inch longer.

The auricles resemble those of the whale, having the same transverse ligamentous bands.

The valves had nothing particular in their appearance.

* Plate LI.

The foramen ovale was entirely closed, but its situation was distinctly seen.

The relative size of the aorta and pulmonary artery was the same as in the elephant.

If we take a review of all the different modes of circulating the blood, which have been stated in this Lecture, we shall have to contemplate the great power, and the unfathomable wisdom of the omniscient Creator, who has not only employed means almost endless in their variety, but every way peculiarly adapted to the animal to which it belongs, so as to give it some decided advantage in velocity, facility, or strength.

LECTURE VII.

On the Skeletons and Progressive Motion of Animals.

[Continued from the Fifth Lecture in the First Volume.]

Since the First Volume of the present work was published, the skeletons of new animals have been brought under my observation, both of those that at present inhabit our globe, and of those long since extinct, and only met with in a fossil state.

The mechanism by which insects are capable of walking against gravity, and animals whose weight renders them less fitted for that purpose, has been also discovered by the microscopical observations of Mr. Bauer, by which our knowledge in Comparative Anatomy is greatly advanced.

The stomach and teeth of the dugong and manatee have been described, and I shall here take notice of their skeletons. That of the dugong is made up of fifty-two vertebræ; seven to the neck, eighteen to the back, twenty-seven to the tail.

The sternum in the young animal is ligamentous, in the middle where the cartilages join it, which appears to allow of a bend in the chest; but this part afterwards becomes bone.

The scapulæ are broad and thick, the os humeri short and strong, the radius and ulna are of unusual breadth.

There is a bony canal on the anterior part of the spine, from the anus to the end of the tail, in which the great blood-vessels are inclosed: the spinal processes of these vertebræ are attached by ligamentous union.

There is only one bone in the thumb, and the same in the little finger: this last is the broadest, and therefore it is more like a thumb than the real one.

The bones of the skeleton of the dugong, when mounted, give us a form very different from what is met with in the whale-tribe, and may be compared to a boat without a keel, with the bottom uppermost; so that in the sea, the middle part of the back is the highest point in the water; and as the lungs are extended to great length on the two sides, close to the spine, they furnish the means of the animal becoming buoyant; and when no muscular exertion is made, the body will naturally float in an horizontal posture.*

The skeleton of the manatee, which may be called the dugong of the West Indies, bears so close a resemblance to the dugong of the East Indies, as not to require a separate description, its mode of progressive motion being the same. There is, however, a peculiarity that appears to render it fitted for the fresh-water rivers it inhabits, while the dugong belongs to the sea. This is, the ribs being more extended,

* Plates LII. LIII. LIV.

giving the animal greater breadth, so that it can float in a lighter medium. The transverse processes of the vertebræ of the loins are broader.*

When we consider that this tribe of animals is the only one yet known that grazes at the bottom of the sea, (if the expression may be allowed,) and is not supported on four legs, we must admit that it will require a particular mode of balancing its body over the weeds upon which it feeds.

The hippopotamus, an animal that uses the same kind of food, from the strength of its limbs supports itself under water; and the dugong, as a compensation for not being able to support its body on the ground, has means of steadily suspending itself in the sea peculiar to itself, the centre of the back forming the point of suspension, similar to the fulcrum of a pair of scales. This peculiarity of position explains the form of the jaws, which are bent down at an angle with the skull, unlike the jaws of other animals. This new mode of floating, when compared with that of other sea-animals, makes a beautiful variety.

The balæna mysticetus, that goes to the bottom of unfathomable depths, to catch in its whalebone-net the shrimps that live in that situation, is surrounded with blubber, not unlike a cork-jacket.

The enormous spermaceti-whale, whose prey is not removed to so great a depth from the surface, has the mass of spermaceti placed in a long concavity upon the skull.

In the shark-tribe the oil is situated in the liver, which lies along the two sides of the spine, in some respects like the lungs of the dugong.

* Plates LV. LVI.

The walrus is an animal which I had never seen, till Mr. Brooks, a short time since, gave me an opportunity of examining the fore and hind fins and the tail: it is certainly more nearly allied to the hippopotamus than any other animal.

In the body and tail the resemblance is very close, the general form of both animals being the same unwieldy mass, and the tail in both is nearly of the same length: that of the hippopotamus is broad and flat, consists of fourteen vertebræ, and is twenty inches long, that of the walrus has only ten vertebræ, and is about eighteen inches in length. These are the only two animals that live in water whose tails resemble the quadruped that lives on land.

The head is prodigiously small, when it is compared with the bulk of the body; and the great strength of the tusks must be considered to enable them to sustain the animal's weight.

It is remarkable, that after so many voyages have been made in the northern seas, that not one of the skins or sets of bones have arrived in this country, except that in Mr. Brooks's possession.

Its having posterior fins would appear to make it an approach to the seal; but that is by no means the case, since in the seal the hind legs and tail are enveloped in one common covering, forming the whole into a regular tail not unlike the manatee.

Its anterior fins differ from those of the dugong, in which the five toes are of unequal lengths, the two middles ones long, the two outside shorter, and the little thumb shortest of all, forming only one joint. They differ also from the

manatee, in which the middle is the longest, and those on each side of it shorter, but nearly of the same length, and the next two still a little shorter.

In the walrus the toes are also five; but the longest and much the strongest is in the place of the thumb; and the other four gradually diminish in size: the whole fin is one foot broad. This form is very well calculated for impelling the body through the water. The hind fin is unlike the fin or foot of any other animal I ever saw; it consists of five toes, or, more properly, three toes loosely connected together, like those of a duck's foot; and these are as it were surrounded, or inclosed on each side, by a long curved toe projecting beyond the others. When spread, the fin or webbed foot is two feet broad.

This curious form of foot, of such great breadth, and the two long curved toes encircling the whole, gives me an idea that when this unwieldy animal is ascending the rocks, to prevent its falling backwards, lays hold of the surface by placing this broad expanded foot upon the rock, and, by drawing up the middle toes, retains its hold by suction, in the same manner as the fly's foot does, as will be explained in the course of the present Lecture.

On the Skeleton of the Rhinoceros.

Although the skull and teeth of the rhinoceros from Sumatra have long been preserved in the Hunterian Museum, the whole skeleton had not come under my observation, till Sir Stamford Raffles sent home the bones

from Sumatra, as also those of two species of tapir; one the native of Sumatra, the other of America.

Upon comparing the bones of these two skeletons of tapirs, the bones were found more nearly allied to the rhinoceros than any other animal, and are little different from one another. The skull of the Sumatra tapir has a broader frontal bone, and no middle ridge; the two nasal bones, which in both species have the shape of a heart on cards, stand higher, and are broader, allowing a larger space for the nostrils. In the American tapir, the parietal bones are much compressed, and the os frontis has a considerable ridge.

The molares teeth of the tapir are seven on each side in the upper jaw, and six on each side in the lower: they have no broad plate on the outside; but the indentations on the inside are similar to those of the rhinoceros. The number of the molares on each side of both jaws in the rhinoceros is six. The scapulæ and pelvis of the tapir have less relative extent of surface than in the rhinoceros.

The double-horned rhinoceros of Sumatra in its skeleton differs little from that of the single-horned species of Africa: the projection formed by the united nasal bones is more nearly in a straight line, and more extended, probably to give room for the second horn.

The large bony process projecting from the outside of the thigh-bone, so conspicuous in the rhinoceros, is equally so in both species of tapir: it is met with in the horse, although less prominent; and is to be considered as a mark by which

an alliance is proved to exist between the three genera of animals.*

I cannot conclude my observations on the rhinoceros, without giving some account of a new species from Africa, which leads to the notion of that quarter of the globe being the country which the rhinoceros originally inhabited.

The discovery of a new species of any of the larger animals, now that our globe has been so extensively explored, is an object to the naturalist of great interest; which is increased when there is a striking resemblance between the form and appearance of the skull of this animal and the skull of one of the same tribe, met with only in a fossil state.

It has been hitherto asserted, as one of the most curious circumstances in the history of the earth, that all the bones that are found in a fossil state differ from those of animals now in existence; and I believe that this is generally admitted, and that there is no fact upon record by which it has been absolutely contradicted: but the following observations on a new species of rhinoceros, illustrated by drawings, will go a great way to stagger our belief upon that subject.

The skull of a species of rhinoceros now living in Africa was brought to this country by Mr. Campbell, one of the Missionaries sent there from London, and is deposited in the Musuem of the Missionaries in the Old Jewry.

The following account Mr. Campbell gave me in writing:—

"The animal was shot about two hundred and fifty or three hundred miles up from the westward of Delagoa bay,

* Plates LVII. LVIII. LIX.

six miles west of the city Mashen, and above one thousand miles in nearly a straight direction from the Cape of Good Hope.

"The country from whence the rhinoceros comes contains no thick woods or forests; but is covered with separate clumps of trees, like a nobleman's park in England. In travelling, you always appear to be approaching a wood; but as you advance, the trees are discovered to stand at a distance from one another.

"This animal feeds upon grass and bushes; is not carnivorous, and not gregarious; seldom more than a pair are seen together, or in the same vicinity. Mr. Campbell's people wounded another of the same kind. When enraged, it runs in a direct line, ploughing the ground with its horn. The hide is not welted; is of a dark-brown colour, smooth, and without hair."

The skull which Mr. Campbell brought to England fortunately has the horns in their natural situation: the longest is thirty-six inches.

There are horns of the same kind in the British Museum; one forty-two inches long.*

The horns differ in many particulars from those of other species. The long one stands upon the extremity of the nasal bones, its direction nearly straight forward; the smaller one is so close behind it as to appear intended to support its base. The most curious circumstance is, that the resemblance between this skull and the fossil skull from Siberia is so great, that they must be considered as belonging to animals of the same species.

* Plate LX.

The annexed drawing of a fossil skull* of the rhinoceros is taken from a cast, the original of which is in the Collection at Paris. I have compared it with a specimen in the British Museum, presented by the Emperor of Russia to Sir Joseph Banks, and they were found to be exactly alike.

The closeness of the resemblance between this recent and fossil skull renders it probable that some other animals may yet be found recent, that have been considered as long ago extinct.

When we consider that the course of the Niger, one of the largest rivers in Africa, has not been traced to its source by any European traveller, it must be admitted that there are large tracts of country in that immense continent which remain unexplored; in which these animals, who are not disposed to submit to the will of man, but on the contrary fly from him, can conceal themselves by retiring to fastnesses in the wild forests, which, for ages to come, may never be visited by rational beings.

The following account of the habits of the wild animals in Africa is a curious document, as it both explains how in some instances they may elude the search after them, and in others be accidentally taken.

Mr. Campbell says, that he found that the wild ass or quagga migrated in winter from the tropics to the vicinity of the Malaleveen river; which, though farther to the south, is reported to be warmer than within the tropic of Capricorn, when the sun has retired to the northern hemisphere. He saw bands of two or three hundred, all travelling south. When on his return from the vicinity of the tropics,

* Plate LXI.

various Bushmen, as he proceeded south, enquired if the quaggas were coming. Their stay lasts from two to three months; which, in that part of Africa, is called the Bushmen's harvest. The lions who follow them are the chief butchers. During that season, the first thing a Bushman does in the morning, on awaking, is to look to the heavens, to discover vultures hovering at an immense height; under any of them, he is sure to find a quagga that had been slain by a lion in the night.

It is deserving of remark that the elephant, one of the most powerful and most sagacious of the animal race, has learned to have a pride in the ornaments and trappings with which man, for the purpose of pomp and parade, has clothed him. It would appear that the sagacity of this noble animal had taught him that to live in bondage in the society of man is better than savage liberty; for when he had returned to a wild state, and remained in it for seven years, upon meeting with his former guide, on hearing his voice he came back to his duty.

Immediately after his submission, he voluntarily assisted in securing one of the wild elephants that were taken, by pressing against one of his sides, while his legs were secured. He was an uncommonly fine elephant, and in high condition. This statement, my friend, Mr. Shakespear, assures me is correct, and happened while he was in India.

On the other hand, the rhinoceros is at this day in a savage state, and so stupid as not to be tamed.

The account in the Bible of an unicorn not to be tamed, mentioned by Job, bears so great an affinity to this animal that there is much reason to believe it is the same, no other animal being so devoid of intellect. In that age, the short

horn might readily be overlooked; and the skin being smooth, gives the animal a resemblance to a horse.

On the Fossil Skeleton of the Proteosaurus.

The study of Comparative Anatomy is not confined to the animals that at present inhabit the earth, but extends to the remains of such as existed in the most remote periods of antiquity.

That the bones of the elephant, rhinoceros, hippopotamus, crocodile, and of many other animals, should be met with in a fossil state, in this island, in such numbers as to make it appear that at some distant period they were inhabitants of Great Britain, is perhaps one of the most wonderful circumstances that occurs in the history of the earth.

To account for this change, it appeared to me that there was only one solution: the poles of the earth shifting, in process of time made a change in the heat of the different portions of the surface of our globe. But Sir H. Davy, in investigating the mineral productions of the earth, their crystallizations, and the water contained in these crystals, proves that a very high temperature was necessary to admit of such effects being produced; and as the metals and waters met with at the greatest depth yet explored are at present hotter than the surface is at the equator, there must have been a period of time when the whole globe possessed, within itself, too much heat for carrying on life in animals and vegetables. When this was sufficiently diminished on the surface, tropical animals inhabited it, and lastly man; the heat of the sun compensating for the diminution of that of the earth, which is still going on cooling towards its centre.

To discover the changes that have taken place in our globe which can account for the remains of animals only fitted to live in warm climates being found in so northern a situation, and to explain the circumstance of human bones never having been met with in a fossil state, is the province of the geologist. To examine such fossil bones, and to determine the class to which the animals belonged, comes within the sphere of enquiry of the anatomist, and considerably increases its extent.

This branch of anatomy not only brings to our knowledge races of animals very different from those with which we are acquainted, but supplies many of the intermediate links in the gradation of structure, which are wanting in the present creation; and therefore makes it probable, that when the two are sufficiently investigated, one regular and connected chain will be formed, each class of animals imperceptibly running into that which is next to it.

The proteosaurus, which I am about to describe, is of this kind, partaking of the structure of very different classes; although the skeleton, taken as a whole, does not belong to any one of them.

When it first came under my observation in the year 1814, I ascertained that it did not belong to the tribe lacerta, the intervertebral articulation being cupped, as in fishes. The discovery of this fact, which was published in the Philosophical Transactions, called the attention of those gentlemen who had specimens in their possession; which, while they believed them to be bones of the crocodile, were not much valued; but as soon as they were explained to be something

extraordinary, the collectors, with renewed diligence, searched after others.

The skull I first saw was found in 1812, on an estate of Henry Host Henley, Esq., between Lyme and Charmouth, in Dorsetshire, in a cliff three hundred or four hundred feet above the level of the sea-shore.

The cliff falling, the bones were thrown down, and buried in the sand upon the shore to the depth of nearly two feet. This cliff is composed of that species of argillaceous lime-stone, called blue lias, in which the bones had been deposited. Above the lias there is only a thin layer of black earth.*

As my first publication in the Philosophical Transactions in 1814 had given a new spirit to collectors to examine these cliffs, so it induced many of those gentlemen either to deposit their specimens in the Collection of this College, or give me an opportunity of having drawings made from them.

In this manner I was enabled, in 1816, to lay before the Royal Society the description of many bones not before met with; again, in 1819, to give in two other papers, describing a greater number; and, in the year 1820, still further additions.

As each progressive advance made my friends more zealous in their endeavours to assist in completing the skeleton of this extraordinary animal, I kept up the warmth of the pursuit by publishing from time to time the progress I had made; and thus, by a steady perseverance on my part, and an equal participation of exertion on theirs, at the end

* Plate LXII.

of eight years I am enabled to give representations of all the fossil remains of this antediluvian animal, differing as widely, I may say, if not more so, from all now in existence, than any others yet discovered. The gentlemen from whose labours I have received the greatest assistance are, the Rev. Mr. Buckland, Professor of Geology to the University of Oxford, who has been indefatigable in this cause: Mr. Johnson of Bristol, who has been a collector of fossil remains for twenty-five years; during several summers he devoted ; or six weeks at a time, to a close inspection of the cliffs and beach at Lyme, and in his eagerness to attain bones deposited in perilous situations, he sometimes was in considerable personal hazard: the Rev. Peter Hawker, of Woodchester, and Dr. Carpenter, of Lyme: Mr de la Beche of Lyme, who has exerted himself exceedingly on his own part, and brought me acquainted with the collection of Col. Birch, which contained the most valuable specimens of these fossils yet known; one of these, which is nearly a complete skeleton, this College has liberally purchased at the high price of one hundred pounds.* All the specimens that have been thus brought together came from the neighbourhood of Lyme, in Dorsetshire; but I have received, through the kindness of the late Sir Joseph Banks, a specimen containing five vertebræ, taken from the blue lias at Weston, near Bath, which is so far important, as all the bones of this description collected there have hitherto been considered as belonging to the crocodile.

In describing the different parts of this curious skeleton piece-meal, (if I may so express myself,) I hazarded con-

* Plate LXIII.

jectures upon the analogies of other animals, according to the particular bones discovered; and as the most marked peculiarity was the cupped form of the intervertebral joint, I was long of opinion that the animal must have had a nearer approach to fishes than to any other class; and this impression was only removed by the discovery of the sternum, and the bones of the anterior and posterior extremities.

Although I indulged myself in different conjectures, I never ventured to give a name to the animal till the principal bones had come under my observation; and as its place in the scale of animals proves to be between the lizard and the proteus, I have adopted the name of Proteosaurus, suggested to me by my friend Professor Buckland.

I shall now describe the skeleton, making comments upon the peculiarities of the different bones as I proceed.

The largest skull I have seen was four feet long, in which all the parts of one side of the face and lower jaw are very distinct. The lower jaw had been forced a little backwards: this circumstance gives the jaw a resemblance to that of the crocodile. The teeth are small and conical; they appear to contain the next in succession, which is the case with the crocodile; but the rudiments of the young teeth had not begun to form, for the cavity of the tooth, when split, contained calcareous spar, which had the form of the young tooth.

The sclerotic coat of the eye is made up of bone, formed into thin plates lapping over one another, as in birds; their number is thirteen. The bony coat of one eye was entire; the other had been forced through the cavity of the nostril, and also through the bone of the nose on the opposite side,

forming an orifice, which occurred in so many specimens as to induce the belief that it was a natural appearance; this, however, is not the case, for in a section of the nostrils, it is seen that they are continued on to the point of the nose.*

The vertebræ collected, that appear to form one chain, are about sixty in number; when placed in a line, the skeleton measures seventeen feet: that they are cupped, has been stated, as in fishes; the dimensions of the largest of this chain are one and a half inches thick, three and a half broad, measured transversely, and three inches from side to side. But there must be fossil remains of this animal of very different sizes, for vertebræ have been found belonging to the middle of the back only five-eighths of an inch in diameter, and others of nine inches.† The spinous process and lateral parts of the canal for the spinal marrow, make no part of the vertebra itself, but are connected to its posterior edge by a species of joint peculiar to itself on each side. This mechanism differs from that met with in the lizard and proteus tribe, but resembles the vertebræ of cartilaginous fishes, with this difference, that in them these processes are not bone, but cartilage, and are attached by being indented into grooves in the body of the vertebra; whereas in the proteosaurus they are attached to small projections from that bone.‡ This peculiarity, common to these two very different tribes of animals, has been the means of misleading collectors of fossil remains, so as to class all such vertebræ among those of cartilaginous fishes; and there are many vertebræ in this collection of the

* Plates LXII. LXIV. LXV. LXVI.

† Plates LXVII. LXVIII. ‡ Plates LXIII. LXVIII.

proteosaurus mixed with those of such fishes; they are, however, very readily distinguished by two lateral projections cupped at their extremities, for the articulation of the two portions of their ribs.* The ribs in many specimens are so crushed that the middle line of the bone has a fluted appearance; this, however, is only the effect of pressure; the mode in which they are articulated with the vertebræ, is intermediate between that of fishes and the lizard tribe.

In the chœtadon, from Sumatra, which has large ribs, they have but one attachment to the middle part of the side of the vertebra, requiring no motion upwards, as in animals with lungs, and a sternum; but as this animal has a sternum and lungs, and breathes air, it required that the ribs should have the necessary motion for breathing without interfering with the motion of the vertebræ on one another.

The sternal portions of the ribs are not brought forward as in quadrupeds in general, to be united to cartilages, but as in the cameleon and crocodile, are composed wholly of bone; and, what is peculiar to themselves, each rib consists of one piece, having no intermediate joint; it forms a considerable curve in coming forward, and the portion of rib on the outside of the curve is the broadest and strongest. Their great length gives considerable depth to the chest.

The sternum is composed of two broad flat bones, united together, more resembling in form a scapula than any other bone. Immediately over the junction is a long flat bone rounded at the lower end, and at the upper sending off a process on each side, on this lies the clavicle; which resembles that bone in birds; the upper bone of the sternum

* Plates LXVIII. LXIX. LXX. LXXI.

is laterally connected with the scapula, which is long and narrow; its lower end forms a portion of the glenoid cavity of the shoulder, the rest being furnished by the lower bone of the sternum. This very unusual mechanism has nothing at all analogous to it in any other class of animals except the ornithorhyncus paradoxus, to which it bears a close resemblance.* The use of this very broad surface appears to be to give origin to the great muscles that move the anterior paddle.

The muscles employed for this purpose in the ornithorhyncus, I have dissected, and cannot doubt of there having been similar muscles in the animal to which this skeleton belonged.

There is not only a pectoral muscle going from the first bone of the sternum to the first bone of the paddle, and a small one under it, which may be called the smaller pectoral muscle, but two large muscles which have their origin from the broad flat bones, and go to the first bone of the paddle, or os humeri, and are inserted just below its head; that part being unusually broad to give surface for such attachment. These muscles must be considered as only belonging to animals having this peculiar form of sternum.

The fore-leg, or paddle, consists of a short strong bone, answering to the os humeri, beyond which there is a paddle made up of a number of small bones resembling tessara; there are two in the first row united to the os humeri, four in the next, five in the third, and six in all the others; in one specimen there are fifteen of these rows, in another more than thirty-two. This paddle, for I can give it no other

* Plates LXXII. LXXIII.

name, differs from fins, in being made up of so many distinct bones; from the turtle, in having no thumb, with which to lay hold, which is a distinguishing character of the inhabitants of the sea, that come ashore to lay their eggs.* From the great number of bones it contains, it must have nearly the pliancy of a fin, and much more than in the whale tribe.

The bones of the pelvis very nearly resemble those of the crocodile; but, in every specimen in which I have met with them, they have been too much crushed to have an accurate representation made of them.

The form of the acetabulum must differ from that in the crocodile, to adapt it to the head of the bone corresponding to the os femoris, which is not spherical, but rounded and flattened.

The ossa pubis unite by an extended edge exactly as in the crocodile, and anteriorly there are two flat marsupial bones; these are also met with in the crocodile.

The ossa femorum, and the tessara composing the posterior paddle, are less in size than those of the anterior.

Although all the bones that I have described belong to one species, there is sufficient evidence to prove that there are very different species, which vary among themselves exceedingly in size.

In one species, specimens of which I have met with, the upper jaw is much longer, narrower, and comes more to a point; the teeth so loosely fixed in the jaws that hardly any are met with in their sockets; that part which had been enclosed by the gum was grooved; the other portion very

* Plates LXXIV. LXXV.

slender, with a polished surface*, and comes to a sharp point.

The os humeri and os femoris, are flatter and broader in this second species, and both send down a small process between the two tessara, with which they are articulated; there is also a deep notch on the outer or lower side of one of the tessara of the first row.

Having, from the materials that have been at different times collected, given a detailed description of the whole skeleton, and having considered the analogies and relations it bears to the skeletons of other animals, I shall now offer my reasons for calling it proteosaurus, and placing it between the lizard and the proteus.

As the cupped vertebra is the great distinguishing character of this skeleton, and that alone which separates it from the lizard, I was led to enquire whether it was the only quadruped in which this peculiarity existed. In this investigation I ascertained that not only the proteus from Germany, that from Carolina, but the axolotle from Mexico, all have cupped vertebræ, and therefore in this respect are allied to it. That the proteus is a perfect animal, I have never doubted, since the time M. Cuvier explained that the bones which he had examined, of those from Carolina as well as Germany, were full grown; and although he has expressed his doubts respecting the axolotle from Mexico, believing, from its resemblance to the larva of the salamander, that it might be a larva of that animal, but it being now ascertained to have cupped vertebræ, as well as the others, which the salamander has not, this question is set at rest,

* Plate LXIV.

and the three different genera of proteus, agreeing in having lungs and gills, and feet, as well as cupped vertebræ, are thus separated by these peculiarities from every other class, as no other has two modes of breathing, one air, the other water; and two modes of progressive motion, one adapted to land, the other to water.

The proteus must then have a permanent place between lizards and fishes; and this extraordinary skeleton of an animal breathing air, and having feet as well as cupped vertebræ, belongs to a class immediately above the proteus.

In its breathing it resembles the lizard, not breathing through the head like the whale tribe, but through the point of the nose.

The paddles being formed of bone, give the animal a power beyond what fishes possess in their pectoral fins; and if it is not equal to that of the bony fins of the whale and dugong, yet, from the greater play of the parts on one another, the paddle may have advantages. From the form of the sternum and the strength of the muscles, the animal probably fed at the bottom of the water, which I believe the ornithorhyncus does, and requires this power of muscle to bring it more rapidly to the surface, for the purpose of breathing.

In its progressive motion the cupped vertebræ give it all the advantages of the squalus maximus in passing through the water; and the paddles being composed of solid bones, the resistance they can oppose to the water must be more powerful.*

* Plates LXXVI. LXXVII.

On Progressive Motion against Gravity.

The house fly, as is well known, is capable of walking upon the ceilings of rooms; in which situation its body is not supported on the legs: but the principle, by which it is enabled to do so, has never been satisfactorily explained; owing to the animal being too small for the feet to be submitted to anatomical investigation.

I was not aware that any animal of a much larger size was endowed by nature with a power at all similar, so as to admit of this very curious subject being investigated, till the late Sir Joseph Banks, in the year 1816, mentioned that the lacerta gecko, a native of Java, comes out of an evening, from the roofs of the houses, and walks down the smooth hard polished chinam walls, in search of the flies that settle upon them, which are its natural food, and then runs up again to the roof of the house. The late Sir Joseph Banks while at Batavia, amused himself in catching the lacerta gecko, by standing close to the wall, at some distance from the animal, with a long flattened pole; which being made suddenly to scrape the surface of the wall, knocked the animal down.

He procured for me a specimen of a very large size, weighing five ounces three quarters, avoirdupoise weight; which has enabled me to ascertain the peculiar mechanism by which the feet of this animal can keep their hold of a smooth hard perpendicular wall, and carry up so large a weight as that of its body.*

* Plate LXXVIII.

The foot of the gecko has five toes, at the end of which, except the thumb, is a very sharp claw, much curved; on the under surface of each toe are sixteen transverse slits, leading to so many cavities or pockets; the depth of which is nearly equal to the length of the slit that forms the orifice; they all open forwards, and the external edge of each opening is serrated, like the teeth of a small toothed comb. The cavities, or pockets, are lined with a cuticle, with which the serrated edges are covered.

On each side of the bones of the toe, which are three in number, is situated a large muscle, of an oval form; its origin is at the tarsus, the fleshy portion extends to the end of the first bone of the toe, and the tendons of both are continued on to the claw, which is moved by these muscles. From the tendons of these large muscles, two sets of smaller muscles originate; one pair of which is lost upon the posterior surface of each of the cavities, or pockets, that lie immediately over them.*

The large muscles, by their contraction, draw down the claw, and necessarily put the small muscles that go off from the tendons of the larger upon the stretch, so that under such circumstances they act to a greater advantage. When these contract, they open the orifices of the cavities, or pockets, to which they belong, and turn down the serrated edge upon the surface on which the animal stands.

On each side of the toes there is a large fold of skin, giving the toes an unusual breadth.

The cavities or pockets, which have been described, and the muscles connected to them, form the only peculiarities in the foot of this particular species of lizard.

* Plate LXXIX.

Upon examining attentively the under surfaces of the toes, when the cavities or pockets are closed, they bear a considerable resemblance to the surface of that portion of the head of the echinus remora, or sucking fish, by which it attaches itself to the shark, or the bottom of ships; it, therefore, suggested itself, that much useful information, applicable to the present subject, might be derived from the examination of such an apparatus, more especially as the parts of which it is composed, are so much larger in size and more within the reach of examination.

The surface on the top of the head of the echinus remora, fitted for adhesion, is of an oval form, and bears a considerable proportion to the size of the whole animal; it is surrounded by a broad, loose, moveable edge, capable of applying itself closely to the surface on which it is placed.

The apparatus itself consists of two rows of cartilaginous plates connected by one edge to the surface on which they are placed: the other, which is external, having the same serrated appearance, described in the mechanism of the toes of the lacerto gecko. These plates are capable of being raised and depressed at the will of the animal; there being muscles upon the skull adapted to that purpose. The two rows are separated by a thin ligamentous partition; and the only apparent reason for their being so divided, is to render them more manageable; as the two portions in every respect resemble one another.

It is evident, that when the external edge of this apparatus is closely applied to any surface, and the cartilaginous plates are raised up, the interstices must become so many vacua; and the serrated edge of each plate will keep a

sufficient hold of the substance on which it rests, to retain it in that position, assisted by the pressure of the surrounding water, without a continuance of muscular exertion.

It thus appears, that the adhesion of the echinus remora is produced by so many vacua being formed by an apparatus worked by the voluntary muscles of the animal, and the pressure of the surrounding water.

From the similarity of the mechanism of the under surface of the toes of the lacerta gecko, there can be no doubt, that the purpose to which it is applied, is the same; but as in the one case, the adhesion is to take place under water, and is to continue for longer periods, the means are the more simple.*

In the other, where the mechanism is to be employed in air, under greater disadvantages with respect to gravity, and is to last for very short periods, and then immediately afterwards be renewed, a more delicate structure of parts, a greater proportional depth of cavities, and a more complex muscular structure becomes necessary.

Having ascertained the principle on which an animal of so large a size as the lacerta gecko, is enabled to support itself in its progressive motion against gravity, I felt myself more competent to enquire into the mechanism by which the common fly is enabled with so much facility to support itself in still more disadvantageous situations.

In the natural size of the feet of the fly, they are so small that nothing can be determined respecting them; and when highly magnified, by an unskilful person, such is the liability to error, that any person with a preconceived opinion

* Plate LXXX.

becomes an improper observer of the appearances that are represented.

From this consideration, I have not examined them myself, but have rather chosen to refer to the representation of their structure taken by others.

Mr. George Adams, mathematical and optical instrument maker, in Fleet-Street, London, in the year 1746, published a plate representing the appearance of the fly's foot, when highly magnified.*

His account of the uses of the different parts is by no means satisfactory, but he concludes it by saying, "That "the fly is enabled to walk on glass, proceeds partly from "ruggedness of the surface, or a kind of tarnish, or dirty, "smoaky substance, adhering to the surface of that very "hard body; and though the pointed parts (of the fly's foot) "cannot penetrate, yet they may find pores enough in the "tarnish, or at least make them. This structure Mr. Hook "surveyed with great diligence, because he could not com-"prehend that if there was any such glutinous matter in "those supposed sponges (as most that have observed that "object in a microscope have believed), how the fly could "so readily unglue and loosen its feet; and also because he "had found no other creature any ways like it."

Jean Christolfe Keller, painter at Nuremberg, made a drawing of the fly's foot in a highly magnified state, which was published in 1776.

The author of the publication to which these plates are annexed, whose name is not mentioned, takes some pains to refute the opinion of Mr. Reaumer, who calls the surfaces

* Plate LXXX.

of the soles of the fly's-feet, pelote or balls; which this author ascribes to Mr. Reaumer not having seen them sufficiently distinctly. This author says, that they are not balls, but concave surfaces, as Keller represents them; a copy of which representation is annexed.

Although the author states them to be concave surfaces, he says that they are only used when the fly moves horizontally; but when it moves perpendicularly, or upon a ceiling, they are turned up out of the way; and the progressive motion is carried on by crotchets into the irregularities of the surface on which the fly treads, whether glass, porcelain, or any other substance. It will, however, scarcely be doubted from the preceding facts, that these concave surfaces are employed to form vacua, which enable the fly to move under such disadvantageous circumstances, upon the same principle as the lacerta gecko.

My observations on the feet of the lacerta gecko and fly, led Mr. Bauer, of Kew, to make drawings of the feet of both these animals. In the hands of an artist who had attained such excellence in the correct representation of objects highly magnified, the mechanism by which the feet are fitted for supporting the weight of the animal against gravity, is much better shown.

Mr. Bauer has not confined his labours to these objects, but has applied the powers of the microscope to the examination of the feet of other insects; and has enabled me to show, that the principle on which progressive motion against gravity depends, is very extensively employed by nature, in the structure of the feet of insects; indeed the

means employed for this purpose are so various, as to form characters by which many genera may be distinguished.

I shall not enter farther into this enquiry than to show some of the varieties of this structure.

The facts I have stated respecting the feet of insects, now that they are known, can be very readily demonstrated, by looking at the movements of the feet of any insect upon the inside of a glass tumbler, through a common magnifying glass; the different suckers are readily seen separately to be pulled off from the surface of the glass, and applied to another part.

The pockets on the under surface of the toes of the lacerta gecko, show that what looked like a pectinated edge when seen through a common magnifying glass, consists of a complex structure, composed of rows of a beautiful fringe, which are applied to the surface on which the animal walks against gravity; while the pockets themselves are pulled up by the muscles attached to them, so as to form the cavities into suckers.

In the blue-bottle fly, the suckers are two in number; they are connected to the last joint of the toe, immediately under the root of the claw, and have a narrow infundibular neck attached to the toe, which has the power of motion in every direction. When these suckers are to be employed, they are separated from each other, and the membrane of each is expanded, so as to increase the surface; but when disengaged, they become nearly closed, and are brought together so as to be confined within the space between the two claws.*

* Plate LXXXI.

The external edge of each sucker is beautifully serrated, and the concave surface is granulated. When the fly is walking against gravity, and its motions are observed, they all appear to be the result of muscular action regulated by the will of the animal.

All the six toes are supplied with suckers.

In the horse-fly, the tabanus of Fabricius, the suckers differ from those of the blue-bottle fly, in being three in number: in all other respects they are the same. In this fly, when the suckers are not used, the two outer ones, close in before the other; and are only spread out when they are brought into use.

In the yellow saw-fly, the cimbex lutea of Fabricius, the suckers are differently situated from those of the fly; they are placed upon the under surface of the four first joints of the toes, one sucker upon each.* These suckers are spoon-shaped.

The exterior part is thin and pellucid, but at half their depth they suddenly become thicker in their coats, forming a ridge at this part, which gives the appearance of an inner cup, but this is a deception; the exterior membranous portion is alone expanded on the surface to which the sucker is applied, and the neck of the sucker forms the vacuum.

All the six have suckers.

The apparatus which has been described to support the animal in its progressive motion, is also applied to other purposes. In the great water-beetle, the dytiscus marginalis, in which there is no appearance of suckers, on the under side of the feet of the female, they are placed on the three

* Plate LXXXII.

first joints of the first and second pair of feet of the male, from which it is evident, that such suckers are used to retain the female in the embrace of the male. In the male, the three first joints of the feet of the fore-legs have the form of a shield, the under surface of which is covered with suckers, one very large, a second, one-third smaller, and all the rest very small. In the second pair of feet, the corresponding joints are much narrower in proportion, and are covered on their under surface with very small suckers.

All these suckers have long tubular necks which show more plainly than in the others the mode in which the vacuum is produced; it is exactly similar in its effects to that of a piece of leather with a string in the centre, applied in a moistened state to the surface of a stone.*

Having explained this apparatus, so beautifully contrived to attach the feet to the surface on which the animal moves, I shall conclude this Lecture by an account of a structure of a very different kind, for the purpose of taking off the jar, when the body of the insect is suddenly brought from a state of motion to a state of rest: this is met with in the grilli and locusta.

Some of them have suckers at the ends of the toes, others have not.

In a species of grillus with a corcelated thorax, brought from Abyssinia by Mr. Salt, the feet are made up of three joints: on the under surface of the first are three pair of globular cushions, filled with an elastic fibrous substance, looser in its texture towards the circumference, which renders it still more elastic: under the second joint is one pair of

* Plate LXXXIII.

similar cushions, and under the last joint immediately between the claws is a large oval sucker. A similar sucker is met with between the claws in a British grasshopper,—the acrydium biguttulum. (Latr.) These are common to all the six feet.

In the locusta varia, whose feet have four joints,—under the first are two very small globular cushions, and two large oval ones: under the second, a corresponding pair of oval ones; and under the third, a pair of cushions different from the others, in being much larger, globular, and semi-transparent: there is no sucker between the claws; and this insect has no power of supporting itself against gravity.*

As the flea has powers of jumping not exceeded by any other insect, it was natural to expect a similar apparatus under its feet; but as no such cushions are met with, we must conclude that the lightness of its body rendered them unnecessary.

* Plate LXXXIV.

LECTURE VIII.

On the Eye.

I shall commence this Lecture with an account of the different parts that constitute the organ of vision, as seen in the microscope; and out of this anatomical investigation I hope the great question which has so long occupied the philosopher's attention, and employed the anatomist and mathematician, will be set to rest. It certainly will prove to be the most accurate and minute examination that has been made of this organ.

The question I allude to is the adjustment of the eye to see objects at different distances: I hope also to explain upon what depends the power of the bird's eye, to look down from infinite space upon the surface of the earth.

For this accurate examination of the parts, we are indebted to the microscopical observations of Mr. Bauer, without which they could not have been made.

At my desire, he examined the structure of the retina, and optic nerve. The optic nerve he found to consist of many bundles of extremely delicate fibres, formed of minute

globules, connected together by a gelatinous substance, which readily dissolves in water. The dimensions of the globules measured on the micrometer are from $\frac{1}{2800}$ to $\frac{1}{4000}$ parts of an inch, mixed with very few of $\frac{1}{2000}$ parts,—the size of the red globules deprived of their colouring matter.

The retina appeared to be a continuation of the bundles that compose the optic nerve, which consist entirely of the same sized globules connected into fibres, from the end of the nerve: the fibres of the retina appear like rays spreading towards the circumference, where they almost disappear, and end in a smooth membrane.

The whole retina is interwoven with innumerable blood-vessels, both arteries and veins: the gelatinous substance that holds the globules together dissolves in water very readily; so that if the parts are soaked in water for three or four days, with a portion of the optic nerve, they become a mass of globules; and the blood-vessels when separated form a beautifully delicate net-work, their branches anastomosing freely with one another.*

By the discovery of this transparent substance we become acquainted with the nature of the medullary structure of the nerves, and can form some idea of their action, which till now I confess myself to have been totally unacquainted with.

The nerves as well as the retina are composed of this newly discovered transparent substance, which is very elastic and soluble in water, and in globules of $\frac{1}{2800}$ and $\frac{1}{4000}$ parts of an inch in diameter. The transparency and solubility of this substance account for its having remained concealed,

* Plate XII. fig. 4.

and were it not coagulable, in which state it acquires a degree of opacity, its existence might still be considered equivocal.

I shall describe the small aperture which was discovered in it by Mr. Soemmering, the first account of which was sent me by my friend Mr. Maunoir, an eminent surgeon in Geneva, in the year 1798.

The mode I adopted for examining the retina was removing the cornea; then the iris, disengaging the lens by wounding its capsule anteriorly, but leaving entire the posterior portion which adheres to the vitreous humour; by this means the retina remains undisturbed, and can be accurately examined when a strong light is thrown on the eye.

The aperture in the retina surrounded by a zone, with a radiated appearance, was distinctly seen on the temporal side of the insertion of the optic nerve; and about one-sixth of an inch from it.*

At first I believed it necessary for the eye to be recent to show this aperture; I have since found that it is more readily seen two days after death; the zone being of a deeper colour the second day. I have succeeded in preserving this appearance after the eye had been kept in spirit.

In separating the vitreous humour from the retina, I found a greater adhesion at this particular part, and when that humour was removed the retina was pulled forward, forming a small fold, in the centre of which was this aperture.

* Plate LXXXV. fig. 1, 2.

Having examined this aperture in the human eye, and ascertained the best mode of bringing it to view, I determined upon investigating this subject in other animals, beginning with the monkey.

The eye was examined immediately after death in the same manner as I had done the human eye. On the first view nothing was to be seen but the entrance of the optic nerve, every other part of the surface being transparent.

Watching it constantly, and renewing the hot water so as to keep up the temperature of 100°, in two hours the retina had acquired sufficient opacity to be distinguishable, and immediately after, the orifice in it became visible; it was a circular hole with no colour at the margin; in half an hour the zone showed itself: when examined with a lens in a bright light, there were four rays at right angles. The orifice remains distinct after the parts have been put into spirit, but the rays have disappeared.

In the eye of the bullock, there is no such appearance; there is, however, a semi-transparent tube resembling the coats of a lymphatic vessel, which terminates in the vitreous humour.

This tube is most distinctly seen some hours after death; and is more obvious in some eyes than others. When the eye has been kept twenty-four hours, there is a circular zone a shade darker than the rest of the surface in which the entrance of the optic nerve is included. When this zone, which is nearly seven-twentieths of an inch in diameter, is attentively examined, the tube will be found in the centre.*

* Plate LXXXV. fig. 4, 5.

The tube seems to be confined by the vitreous humour, and only to move with it while entire; and when this humour is divided the tube falls down.

From the attachment of the margins of the orifice in the human eye to the vitreous humour, I have no doubt of this orifice being the trunk of the lymphatics of that humour, the coats of which are commonly too transparent to be visible, but in the bull and sheep can be detected.

After having got thus far, I wished Mr. Bauer to ascertain whether the marsupium in birds is muscular, as I had formed such an opinion in an early period of this investigation.

After the most careful examination he has decided that it is not; its texture being that of a firm vascular membrane, as represented in the annexed drawing*, and stated by Dr. Young.

The real structure of the marsupium being thus established, I was led to enquire what parts contained within the globe of the eye are possessed of muscular fibres, believing that no other structure can change the place of the crystalline lens, so as to fit the eye to see objects distinctly at different distances.

It is asserted in Blancard's Lexicon, that the ciliary processes are muscular, and that their use is to adjust the eye: the positive manner in which this is stated makes it evident that this opinion at that day was not controverted.

Mr. Bauer, on examining these processes, found that the anterior layer, the part alluded to by Blancard, is made up of eighty processes, lying directly behind the iris, and with

* Plate XC. fig. 2.

it firmly attached at their base to the choroid and sclerotic coat: these are membranous, the surface next the lens concave, the anterior convex.

Behind these, interposed between the membranous processes just mentioned, are bundles of muscular fibres of considerable length, which, I believe, have not before been described: they originate all round from the capsule of the vitreous humour, pass forward over the edge of the lens, attached firmly to its capsule, and there terminate. They are unconnected with the ciliary processes or iris, and their contraction will pull the lens towards the retina. In the human eye and that of the quadruped, they form bundles with intermediate spaces: in the bird, they form a continued layer of muscular fibres, $\frac{25}{100}$ of an inch long.*

The choroid coat which may be said to terminate anteriorly at the ciliary processes is membranous in its structure, and contains lymphatic vessels, one running on each side of every principal artery. These have never before been noticed.†

In the tapetum lucidum, at the bottom of the eye of some quadrupeds, the nigrum pigmentum is principally deposited between the sclerotic and choroid coat. In the human eye and that of the bird, between the choroid coat and retina, a thin pellucid covering being interposed between it and the expansion of the optic nerve, the marsupium has a similar covering between the nigrum pigmentum and the vitreous humour.

* Plates LXXXVI. LXXXVII.

† Plate XCI. fig. 4, 5.

The colour of the pigmentum differs in its intensity according to the colour of the hair of the animal, and when it is white, appears altogether wanting.

That the arteries of the choroid coat deposit the nigrum pigmentum is in some measure proved by fine injection escaping from their extremities; forming a layer behind the retina, without any appearance of extravasation.

The membrane next the retina has been described by Dr. Jacob of Dublin, in the Philosophical Transactions*: the pigment appears nothing more than the colouring matter of the blood, having taken on that colour when separated from the globules.

The arteries of the ciliary processes in the horse are very large; and I am led to believe that the two species of worm, the strongylus armatus, and filiaris papillosa, found alive in the aqueous humour, in that animal in India, get there through these arterial branches; more especially as they are known to exist in the circulating blood of that quadruped.

The iris is fixed at its origin to the annular ligament, and is divisible into two layers: the posterior muscular, the fibres radiating towards the pupil, the edge of which forms a regular sphincter muscle; the anterior layer is membranous.

Many people acquire a power over the action of these muscles, so as to render them voluntary.

My friend, Mr. Maunoir, of Geneva, is, I believe, the first person who made out this structure, and gave an engraving of it. I have much pleasure in stating that what he represented in the quadruped corresponds with Mr. Bauer's

* Plate XCI. fig. 1.

drawings from the human eye, made before Mr. Maunoir's Treatise on the artificial pupil was shewn to him.

The capsule of the crystalline lens is made up of two hemispheres of different texture, in which the lens is inclosed; the anterior portion the most dense of the two.

The posterior is so thin, as to appear a continuation of the capsule of the vitreous humour only; but from its curling up when cut, it must partake of the same nature as the anterior portion.

The structure of the lens itself is well known; and Mr. Bauer has ascertained that the fibres of which it is composed have no appearance of muscularity, but of hairs or fine spun glass: indeed muscular action would interfere with the regular transmission of the pencils of rays of light to the retina.

The vitreous humour consists of a very delicate gelatinous substance, exceedingly elastic, abundantly supplied with vessels; which, although they do not carry red blood, are capable of being injected. This gelatinous humour dissolves so rapidly after death, that it is generally described as being of an aqueous nature.

The marsupium in the bird's eye does not project forwards directly in the middle line of the curve of the retina; but is so situated, that the surface within the optic axis forms a larger curve than the surface on the outside of that axis; the two curves are to one another as eight-fortieths of an inch to seven-fortieths.

This microscopical examination of the internal parts of the eye is so minute, that it will be readily admitted no part can have been overlooked; and, therefore, we may consider

ourselves fully in possession of all the materials by which the various functions of that most curious organ are performed.

Two new facts are brought to light: one, the muscle of the lens, which arises from the capsule of the vitreous humour, and is inserted into the capsule of the crystalline lens; the other, a difference in the curve of the retina, on the side of the marsupium, in the bird's eye, within the optic axis, from that on the opposite side.

I shall attempt to explain the uses of the new muscle, and of the marsupium, under the circumstances in which it is placed; for, although these have been considered more as questions in mathematics than physiology, I must be allowed to point out, that mathematical measurements cannot be applied to either living or dead bodies. This arises from the great difference that is produced in all living parts, immediately after they have been deprived of life; which no one but those whose profession it is to perform operations upon parts that are alive can have an idea of. The sartorius muscle, when exposed, in the operation for the popliteal aneurism, is found four times broader than in the dead body, however recently examined.

The action of the iris is seen in the living body through the cornea: in the dead body, its muscular structure is scarcely to be ascertained, being even more minute than that of this new muscle. How then, I ask, can we measure the dimensions of parts of animal bodies with mathematical exactness after death, when those dimensions have undergone so great a change? At the very best it can only be an approximation, and that a very imperfect one.

When I mention, that all the ingenuity of the late Mr. Ramsden was unable to decide, whether, in the adjustments of the eye, there is an alteration produced in the curvature of the cornea, who will venture to decide, with mathematical correctness, the figure of any of the parts of the human body, that are capable of having motion produced in their internal structure?

Since the dimensions of living parts, or the extent of their motions, are not to be come at by any actual measurement, we must give up mathematical proofs, and be satisfied if mathematical reasoning is not against the proof given.

If it is admitted by mathematicians, that the adjustment of the eye to distant objects can be produced by the lens being moved nearer to the retina; and a muscle is discovered that can produce such a motion; and, at the same time, no other mode can be devised by which this effect can be performed; as a physiologist, I come to the conclusion, that this muscle produces it, although I have not the exact data required by a mathematician to bring me to it. Allowance is to be made for combined actions of parts in living animals, which are too rapid, and too minute for me to follow, being capable of rendering the effect complete.

The iris, we know, is acted upon by light, so as to adapt the aperture to the quantity required for distinct vision, and this aperture admits of being measured.

The same involuntary power is probably acquired by the muscle of the lens, to adapt its distance from the retina to distant objects; the lens being brought forward, by other means, when the distance of the object is such as to require its being so.

Having discovered a muscle belonging to the lens, whose fibres are $\frac{25}{100}$ of an inch long, and knowing, from other observations, that muscular fibres can contract to one-half of their length, I cannot doubt of the lens being moved through that space by this muscle; and when Mr. Dollond, who is more competent than most other men, by his knowledge of optical instruments, to give an opinion on the subject, assures me, that, according to his judgment, such a change of place in the lens is sufficient to account for the adjustment of the eye, it is impossible for me to doubt of its being done in this way, in the absence of all other means for that purpose.

It is no small corroboration of this being the use of the muscle, a similar muscle being employed to tune the ear, by tightening the drum.

It is now ascertained that when the crystalline lens is removed, there is no longer a power of adjusting the eye; but so great is the compensation produced by diminishing the size of the aperture, that both Mr. Ramsden and myself were deceived, and believed that such power still existed, till experiments with Dr. Young's optometer exposed the error.

The following experiment, made with the belladonna upon the eye of a gentleman, sixty-nine years of age, who had been myopic from his earliest infancy, and in that respect found no increase or diminution as he advanced in life, proves that although the influence of the belladonna increases the size of the pupil beyond that of the other eye, the adjustment remains the same; the muscle of the lens in myopic eyes of long standing losing in degree the power of contraction, probably from want of use.

The experiment was made October 9. 1821, with the assistance of Mr. Dollond, who had contrived an instrument to measure accurately the size of the pupil in its different changes. A circular hole in a board was placed opposite the eye, in which a telescope was screwed from the opposite side, and through this the examinations were made. The focal distance of the right eye having been ascertained to be seven inches, that of the left, five inches.

A drop of prepared belladonna was dropped into the right eye, exactly at five o'clock: at half past five, the pupil was dilated to twice the size of the diameter of the other; and this eye could now only see objects at the same distance as the other eye, when adjusted to its greatest range of vision, which was thirteen inches.

At six o'clock, the pupil had become two and a half diameters larger than the other, when at rest; but its extent of vision was not increased: when a candle was brought near the eye, there was an evident contraction, although in a small degree.

At eight o'clock, the aperture of the pupil had become stationary, the iris admitting of no farther dilatation: the candle now had no effect upon the pupil.

The aperture of the left eye when at rest, compared with the right, was as one hundred and eight to three hundred: but when the left was adjusted to the distance of thirteen inches, the pupil enlarged so much as to be nearly doubled, and was then to the right as one hundred and ninety to three hundred; but immediately upon withdrawing the object, returned to its natural size.

In this state of the pupil, which continued for three days,

the person was capable of seeing an object at thirteen inches, equally well with both eyes, although the apertures were not the same; but no object to the right eye was distinct at any other distance.

When Mr. Bauer had determined that the marsupium in the bird's eye was a structure made up entirely of membrane, I asked Mr. Dollond what optical purpose a screen of that description could answer? I mentioned, at the same time, that the division of the retina was not into two equal parts; but, in all the eyes I had examined, the portion within the optic axis was much larger than that on the opposite side.

Upon looking attentively at a drawing of a section of the eye of an eagle, he said immediately, If the retina on both sides of the marsupium has the same degree of sensibility, that which lines the greater curve, being more distant from the lens, will adapt the eye to near vision; that on the smaller curve being nearer the lens, will fit the eye for seeing distant objects; the marsupium confining the rays to either when required; the nicer part of the adjustment to intermediate distances being performed as in the human eye. In confirmation of this opinion, the marsupium in the walking birds, as the emu, being very narrow, but in birds of prey very broad.

The following instance will sufficiently show the wonderful extent of vision of the bird's eye.

In the year 1778, Mr. Baber and several other gentlemen were on a hunting party, in the island Cassimbusar, in Bengal, about fifteen miles north of the city of Marshedabad: they killed a wild hog of uncommon size, and left it on the ground

near the tent. An hour after, walking near the spot where it lay, the sky perfectly clear, a dark spot in the air at a great distance attracted their attention; it appeared to increase in size, and move directly towards them; as it advanced, it proved to be a vulture flying in a direct line to the dead hog. In an hour, seventy others came in all directions, which induced Mr. Baber to remark, this cannot be smell.

Dr. Russel remembers to have observed at Aleppo, in the most serene weather, when not a speck was to be seen in the sky, if any dead animal was left behind by hunting parties, in the space of a few minutes it was surrounded by birds, although just before none were visible.

On the Use of the Nigrum Pigmentum and Rete Mucosum.

To ascertain the use of the black colour of the nigrum pigmentum in the eye, and of the rete mucosum in the Negro, has occupied the attention of many physiologists; and I confess that this subject formed the first investigation in which I ever engaged.

Fruitless, indeed, were my attempts; and when I learnt that black surfaces absorbed heat, and raised the temperature several degrees beyond any others, I gave the matter up in despair. Four years ago, my attention was again called to this enquiry, upon being told by the late Sir Joseph Banks, that a silver fish, in a pond at Spring Grove, during a very hot summer, immediately after some trees by which the pond was shaded were cut down, was so much exposed to the sun's rays, as to have its back scorched, the surface

putting on the same appearance as after a burn, and rising above the surrounding skin. I saw the fish several times, and directions were given to send it to me when it died; but I was not so fortunate as to receive it.

This extraordinary circumstance brought to my recollection one not less so. In crossing the tropic in April, 1781, at twelve o'clock at noon, in a voyage to the West Indies, I had fallen asleep upon deck, lying upon my back, having a pair of thin linen trowsers on; and I had not slept half an hour, when I was awakened by the bustle attending the demand of forfeits on crossing the line, and found the inside of the upper part of both thighs scorched, the effects of which have never gone off; at the time I could not imagine how it happened.

The effect of the sun's rays upon the fish under water, led me to suspect the mixture of light and heat to be the cause of this scorching effect.

To ascertain the truth of this opinion, I made the following experiments:—

Experiment 1.—In August, 1820, I exposed the back of my hand to the sun at twelve o'clock, with a thermometer attached to it, another thermometer being placed upon a table with the same exposure. That on my hand stood at 90°, the other at 102°. In forty-five minutes blisters rose, and coagulable lymph was exuded, which became vascular under my eye: the pain was very severe.

Exp. 2.—I exposed my face, my eyelids, and the back of my hand to water, heated to 120°: in a few minutes they became painful; and when the heat was further increased, I could not bear it: but no blisters were produced.

Exp. 3.—I exposed the backs of my two hands to the sun's rays, with a thermometer upon each: the one hand was uncovered; the other had a covering of black cloth, under which the ball of the thermometer was placed. After ten minutes, the degree of heat of each thermometer was marked, and the appearance on the skin examined. This was repeated at three different times. The first time the thermometer under the cloth stood at 91°, the other at 85°.

Second time - - -	94°	—	91°.
Third time - - -	106°	—	98°.

In every one of these trials the skin that was uncovered was scorched; the other had not suffered in the slightest degree. There was no appearance of perspiration on either hand.

Exp. 4.—The back of a negro's hand was exposed to the sun with a thermometer upon it, which stood at 100°: at the end of ten minutes, the skin had not suffered in the least.

Exp. 5.—During the eclipse of the sun, on September 7. 1820, I exposed the back of my hand to the rays concentrated by a double lens of half an inch focus, at three different periods of the eclipse. When the heat to a thermometer was 75°, that is, from forty-seven to fifty-seven minutes past one o'clock, (including three of the figures in the annexed drawing, made by Mr. Bauer*,) the concentrated rays felt warm; but gave no pain, although applied for ten minutes.

When the heat to a thermometer was 79°, that is, at fifteen minutes past two o'clock, (including the twelfth

* Plate XCIV.

figure,) the concentrated rays in four minutes gave pain; in five minutes, blistered the skin, and produced dots of coagulable lymph, which became vascular, under the eye.

When the heat to a thermometer was 82°, that is, at half-past two o'clock, (including the thirteenth figure,) the concentrated rays in three minutes gave pain; in four, the part was blistered, and the pain could not longer be endured.

Exp. 6.—September 8. 1820. At eleven o'clock, the heat of the sun 90°, the concentrated rays applied to my naked arm produced a vesicle. This experiment was repeated when the heat was 84°, and in seven minutes a blister formed on the arm.

Exp. 7.—September 9. Eleven o'clock, the thermometer in the sun at 90°. The concentrated rays applied to a piece of black kerseymere cloth, made tight round my arm for fifteen minutes, gave no real pain; and left no impression whatever on the skin, although the nap of the cloth had been burnt.

This experiment was repeated with white kerseymere, the heat at 86°. In fifteen minutes a blister was formed.

Repeated with Irish linen, the thermometer 86°. In fifteen minutes a blister was formed, and coagulable lymph thrown out, which had become vascular.

The same experiment was made with a white handkerchief, loose upon the hand, the heat 83°. In fifteen minutes, an inflammatory blush was produced over a surface of several inches extent, which almost immediately disappeared on withdrawing the hand from the sun's rays.

Exp. 8.—September 12. The sun's heat at noon 85°. The concentrated rays applied to the back of the hand of a Negro from Grenada, for fifteen minutes, produced no visible effect: at the first moment, he felt a stab going inwards; but that went off, and afterwards he had no pain.

From these experiments, it is evident that the power of the sun's rays to scorch the skin of animals is destroyed, when applied to a black surface; although the absolute heat, in consequence of the absorption of the rays, is greater.

The same wise Providence which has given so extraordinary a provision to the Negro for the defence of his skin, while living within the tropics, has extended it to the bottom of the eye; which otherwise would suffer in a greater or less degree, when exposed to strong light; the retina, from its transparency, allowing it to pass through without injury.

That the nigrum pigmentum is not necessary for vision, but only provided as a defence against strong light, is proved by its being darker in the Negro than the European, and being of a lighter colour in fair people than in dark; and, therefore, lightest in those countries farthest removed from the effects of the sun.

In the monkey it is dark, and in all animals that look upwards.

In all birds exposed to the sun's rays, the nigrum pigmentum is black. In fishes, the basking shark, which lies upon the surface of the ocean, has a nigrum pigmentum behind the iris. The turbot and skate, which lie upon banks of sand in shallow water, have nigrum pigmentum.

In all ruminating animals and birds of prey, there is a lucid tapetum at the bottom of the eye.

The owl, that never sees the sun, has no nigrum pigmentum.

The mackarel has the bottom of the eye lucid as quicksilver.

The *coup de soleil*, met with in the West Indies, the effects of which I have seen, I attribute to the scorching effect of the sun's rays upon the scalp.

The Egyptian opthalmia I consider to be the effect of the sun's rays, and the glare of reflected light.

I have stated the fact of the scorching power of the sun's rays being destroyed when they are applied to black surfaces; but have not gone further. Sir H. Davy, to whom I showed these observations, immediately explained the principle.

He said, the radiant heat in the sun's rays was absorbed by the black surface, and converted into sensible heat.

Having made many observations respecting vision in the course of the last forty years, most of which have a place in the Philosophical Transactions, I shall, upon the present occasion, give an account of them; hoping that they are not undeserving of the attention of my audience, nor irrelevant to the great object of this course of Lectures.

The first subject I shall mention is the experiments so well known, made by Mr. Cheselden, to prove that vision alone gives us no idea of distance. This opinion, after having been established ever since the year 1728, was attacked by Mr. Ware, in the year 1801, in a paper laid before the Royal Society, which is published in the Philosophical Transactions. The individuals mentioned by Mr. Ware proved not to have been wholly blind; and before

his death, that gentleman saw the error into which he had been led.

The two following cases, which came under my care in St. George's' Hospital, enable me completely to refute Mr. Ware's remarks. One boy could distinguish light. The sun appeared more red than fire. Lightning made a still stronger impression upon his eye. All light was red. The sun appeared to be the size of his hat; a candle flame larger than his finger, less than his arm. The sun appeared to touch his eyes. When looking at a candle, both eyes were equally directed to it: when nearer than twelve inches, he said it touched his eyes; when further off, it did not; and at twenty-two inches he saw no light.

The other boy was not completely blind, but could distinguish colours with tolerable accuracy, particularly the more vivid ones.

The first boy, immediately after the lens was extracted, could not bear the light: when the eyelids were opened, I asked what he had seen. He said, my head, which touched his eye; and he could not tell its form. The third day he said my face was round and red. He saw several gentlemen, but could not describe their figure. His focal distance was five inches.

This case resembles that related by Cheselden.

In the second boy, (whose case resembles Mr. Ware's.)— Immediately after the eye was couched, the light was not very distressing. Ten minutes after, the following experiments were made: — A round card, of a yellow colour, one inch diameter, was placed at the distance of six inches. He said it was yellow; and if he might touch it, he could tell the shape; but

this being refused, after considering it, he said round. A blue square card, he called blue and round. A triangular one, he called round. He decided correctly upon all colours; but had no idea of form. His focal distance was seven inches. He was asked if objects touched his eye, he said No; but he had no idea of their distance. He was delighted at seeing;—he said it was so pretty even to see the light. He was put to bed, and the eyes covered from light, with the intention of repeating the experiments next day; but he was no sooner alone, than he took off the bandage, unable to resist the temptation, to see and examine the curtains of the bed.

The house-surgeon, finding it impossible to keep his eyes covered, repeated the experiments on the cards, which he still called round; but on being shown a square one, and asked to look for a corner, after some time he said he had found one; and readily counted all four, by making his eye go along the edge, and counting the corners as he came to them. He did the same with the triangle.

In the morning, hearing the music of the Guards, as they passed the window of his ward, he got up to see them. He told me he had seen the soldiers, with their pretty things, allured by the reflection from the barrels of their muskets: a pair of scissors he said was a knife; but on touching it, corrected himself. A guinea, at fifteen inches, he called a seven-shilling piece, but at five inches a guinea; and as often as the experiment was repeated, made the same mistakes. From this time he improved himself by examining every thing he saw with his hands, when within his reach; but often forgot what he had learnt.

On the fourth day he was allowed to play about the ward. He was delighted with what he called dogs drawing wheel-barrows, meaning carts and horses, going along the road.

So little progress had he made in thirteen days, when not allowed to touch the cards, that he was obliged to count their corners before he could tell the forms. In twenty-six days he was able to do it by his sight alone.

Some Observations on the Cornea of the Eye and its Diseases.

The cornea of the eye was compared by Baron Haller to the nails in a soft state; and in its regeneration to the epidermis: so decided was he in the opinion of its being cuticular in its nature.

The cuticle, being devoid of life, is not capable of taking on disease: it may be made to grow in different forms; but when once formed, continues unchanged.

The cornea of the eye we find, on the contrary, undergoes many changes, that exactly correspond with those which the living parts of an animal body go through when under the influence of disease. From this I am induced to consider it alive; and I find that many of the present teachers of anatomy are of the same opinion.

To prove that the cornea has life, it is necessary, as a previous step, to show that sensibility and vessels which carry red blood are not essential to parts possessed of it; for this purpose, all that is required is to demonstrate that other living parts have neither the one nor the other.

Tendons and ligaments in a natural state are instances of this kind. That these parts are not supplied with red blood is obvious to the eye of a common observer; no illustration will therefore be required to substantiate that proof. That they are not endowed with sensibility, was, I believe, first taught by the late Dr. William Hunter*, who published the following account of it†:—

In a case where the last joint of the ring-finger had been torn off, half an inch of the tendon of the flexor muscle projected beyond the stump; this it was thought right to remove; and to ascertain whether it was possessed of sensibility, the following experiment was made:—A piece of cord the thickness of the tendon was passed round the wrist, and along the side of the finger, so as to prôject even with the end of the tendon; the man was then told to turn away his head, and tell which of the two were cut through; the tendon was divided, and the man declared it was the string, not having felt the smallest degree of pain.

This proof is satisfactory; but that the cornea is possessed of life, by no means rests upon any negative proofs; which I shall now endeavour to explain.

The cornea in its structure is made up of membranous lamina. One of these appears to be a portion of the tunica conjunctiva; but it is either so extremely thin, or so intimately connected with the layer next to it, as not to admit of more than a very partial separation from it; another layer is a continuation of the tendons of the four straight

* This doctrine was first taught by Dr. Hunter in the year 1746. Haller made experiments proving the same thing in 1750.

† Medical Observations and Inquiries, vol. iv. p. 343.

muscles; but as both these lamina have the same properties as the other parts of the cornea, and are not to be distinguished from them, they must be considered in every respect as a part of the cornea.*

The tunica conjunctiva and tendons, a continuation of which forms these anterior lamina of the cornea, are allowed to be living parts, and the portions that make part of the cornea are not to be distinguished by their structure from the rest; we must therefore suppose them to be also composed of living parts.

When the cornea is wounded, it unites, like other living parts, by the first intention.

If the wound is made by a clean-cutting instrument the cicatrix is small; but if by a blunt instrument it is larger, extending further into the neighbouring parts of the cornea, a greater quantity of the coagulating lymph of the blood being required to procure the union.

Although the cornea, when divided in the operation for extracting the crystalline lens, commonly unites by the first intention, this union is in some cases attended with inflammation, which produces an opacity of the cornea, in other cases the inflammation exceeds the limits of adhesion, and the whole internal cavity of the eye proceeds to a state of suppuration. These stages of inflammation are only met with in parts possessed of life.

It is true, that an injury may be committed to the cornea, such as a small piece of metal sticking in it, which, from the indolent nature of its substance, shall remain there for months without producing inflammation; but an irritation

* Plate XCV.

of a less violent kind upon the edge of the cornea, by which the tunica conjunctiva is also affected, will produce inflammation upon that vascular membrane, which may extend itself upon the cornea; for it is impossible that the vessels of the cornea, which naturally carry only lymph, or serum, can be made to carry red blood, unless the irritation extends to some neighbouring part supplied with red blood.

That vessels carrying red blood have been met with upon the cornea in a diseased state, is doubted by Haller: he does not altogether deny it; but the assertion, he says, requires proof, as he is not satisfied with the authorities of Petit and others, whom he quotes upon the subject.

It is so common a thing in inflammations of the eye, to have branches of the arteries of the tunica conjunctiva continued upon the cornea, that every practical surgeon must have met with it. In some instances of this kind, which have come immediately under my own care, I have examined these vessels with a magnifying glass, and have seen distinctly small arteries from the tunica conjunctiva, uniting upon the cornea into a common trunk, larger than any of the branches that supplied it; and this trunk has sent off other branches distributed over the cornea.

These vessels may, by some physiologists, be supposed to be continued upon the layer of the tunica conjunctiva, which is spread over the cornea; this, however, is not the case, as they pass behind it, and therefore belong as much to the layer under them as that which is over them; and in many instances of disease, vessels carrying red blood are

met with in the substance of the cornea, still deeper seated. This has been seen by Professor Richter*, who says he divided a thickened cornea, and the vessels in its substance poured out red blood.

The cornea is not only capable of uniting by the first intention, inflaming, and suppurating; but when the inflammation is carried to a great height, a portion of its substance is sometimes removed by ulceration, and the ulcer so formed is filled up by coagulating lymph, which afterwards becomes cornea, acquiring the necessary property of transparency.

This new-formed part is weaker than the rest of the cornea, and commonly projects beyond it, forming one species of staphyloma; in the substance of the cornea, round the basis of the staphyloma, I have frequently seen vessels carrying red blood.

From the opinion of the cornea being devoid of life, the opacities which are found to take place on it, have been considered apart from common surgery, and entrusted to the care of men, who are supposed to have made the diseases of the eye their peculiar study.

According to this theory, the opacity was supposed to arise from a film of inanimate matter laid over the cornea, and upon that idea very acrid and irritating applications were employed, with the view of scraping it off, or destroying it, as powdered glass, powdered sugar, &c. and such

* Richter, Med. Doctor. et Professor Publicus Ordinarius Soc. Reg. Scient. Gotting. et Acad. Reg. Scient. Succiæ-Mem. in Novis Comment. Soc. Reg. Gotting. t. vi. ad annum 1775.

applications being of service, confirmed the opinion which gave rise to the practice.

Having shown that the cornea is possessed of life, I shall now point out the parts of the body it resembles in structure, and to which it bears the greatest analogy, both in its healthy actions, and those arising from disease; and endeavour, by comparing them, to establish some general principle, which will explain the beneficial effects of irritating applications in cases of opacity of the cornea.

The cornea has all the common properties of ligaments, those of elasticity and transparency being superadded.

Like other ligaments it can be divided into lamina, in a healthy state has no vessels carrying red blood, and is devoid of sensibility; when divided, it readily admits of union; when it has become inflamed, is slow in its powers of resolution; when coagulable lymph is deposited, producing an opacity, it is afterwards found difficult of removal, and it can only be done by stimulating applications.

The advantages attending this mode of treating the cornea were probably discovered by accident; and when they were ascertained, it established itself as a very general practice.

It must, however, in the hands of those who had no general principle to direct their practice, have been sometimes applied without benefit, and must have been sometimes injurious.

It is an extremely curious circumstance, and probably the most so that can be met with in the history of medicine, that a local application should have been discovered to be of service in a particular disease two thousand five hundred

and thirteen years ago; that the same application, or those of a similar kind, should have been in very general use ever since, and in all that time no rational principle, on which such medicines produced their beneficial effects, should have been ascertained. This appears from the following account to have been the case, with respect to stimulating applications to the cornea in a diseased state, and can only be accounted for by a want of knowledge of the structure of the parts, which is an argument of uncommon weight in favour of the study of anatomy.

In the Apocrypha we find, in the book of Tobit*, a very circumstantial account of an opacity of the cornea successfully treated by stimulating applications. It is there stated as a miracle; but we have the authority of Jerome, a father of the Church, who wrote in the fourth century to say, "The Church reads the books of Tobit, &c. for examples of "life and instruction of manners, but doth not establish any "doctrine by them."

We shall therefore consider the account which is given in extracts from the book of Tobit in that view.

Tobit, vi. 2. "When Tobias went down to wash himself "in the river Tigris, a fish leaped out of the river, and would "have devoured him.

4. "The Angel of the Lord told him to take out the gall, "and put it up in safety.

* Tobit was of the tribe of Naphtali; in the city of Thisbe, in upper Galilee. He was carried captive to Nineveh, after the extinction of the kingdom of Israel, by Enemassar, or Salmanasser, about the year of the world 3283. —GRAY's *Key to the Old Testament and Apocrypha*, p. 554.

6. "Tobias asked the Angel what was the use of the "gall.

8. "As for the gall, (said the Angel,) it is good to "anoint a man who hath whiteness in his eyes, and he shall "be healed."

Chap. xi. 11. "Tobias took hold of his father, and "strake off the gall in his father's eyes, saying, Be of good "hope, my father.

12. "And when his eyes began to smart, he rubbed "them.

13. "And the whiteness pilled away from the corners "of his eyes; and when he saw his son, he fell upon his "neck.*

* "One of the Paris newspapers gives an account of an extraordinary cure "effected by the gall of a barbel, in a case of blindness, in substance as "follows:—A journeyman watch-maker, named Censier, having heard that "the gall of a barbel was the remedy which Tobias employed to cure his "father's blindness, resolved to try its effects on the widow Germain, his "mother-in-law, whose eyes had for six months been afflicted with ulcers, and "covered with a film, which rendered them totally blind. Censier having "obtained the gall of that fish squeezed the liquor out of it into a phial, and "in the evening he rubbed it with the end of a feather into his mother's eyes. "It gave her great pain for about half an hour, which abated by degrees, and "her eyes watered very much. Next morning she could not open them, the "water as it were gluing her eyes up: he bathed them with pure water, and "she began to see with the eye which had received the most liquor. He used "the gall again in the evening. The inflammation dispersed, the white of her "eyes became red, their colour returned by degrees, and her sight became "strong. He repeated it a third time, with all the desired success. In short, "she recovered her sight without any other remedy. The widow Germain is "in her fifty-third year. She has been pronounced blind by the surgeons of "the Hôtel Dieu; and her blindness and cure have been attested, by order "of the lieutenant-general of police. She sees stronger and clearer than "before the accident." — *Annual Register*, vol. xi. p. 143.

In conversing with my friend, Dr. Russel, on the manner in which the Arabians treat inflammations and opacities of the cornea, he very kindly favoured me with the following account:—

" Respecting the practice of the Arabians in disorders of " the eyes, I find nothing of consequence in my papers. An " oculist, among them, is a distinct profession; and the " collyria they apply are secret compositions, which pass " hereditarily from father to son. The Arabian writers give " a number of recipes, most of which are taken from Galen " and the Greek physicians. One composition in Avicenna " contains the *gall* of a crow, crane, partridge, goat, &c. At " Aleppo, the gall of the sheet-fish (silurus glanis of Linn.) " was in particular request; but it should be remarked, that " they always add to the gall other ingredients, it being a " material circumstance in that country, that a recipe should " consist of a multitude of ingredients.

" What often struck me in their practice was the success" ful application of sharp or acrid remedies, at a time I " should have been induced to make use of the mildest " emollient applications."

From this account given by Dr. Russel, there can be no doubt of gall having continued in use, as an application to the eye among the eastern nations, from the time of Tobit down to the present day.

I have, in the course of the last three years, made many trials of the effects of gall, on the cornea in a diseased state. I have used it pure, and diluted; and compared its effects with those of the unguentum hydrargyri nitrati, and the solution of the argentum nitratum, and find, in old cases of

opacity, it is in some instances the best application. The gall of quadrupeds, in these trials, gave more pain than the gall of fish. The painful sensation was very severe for an hour or two, and then went off. It is proper to observe, that the beneficial effects it produced appeared to be in proportion to the local violence at the time of its application.

The practice of using very stimulating applications to the cornea has stood the test of twenty-five centuries, it therefore can require no support. The object of the present observations has been to explain the principle upon which the beneficial effects depend, a knowledge of which must be advantageous to those who employ this practice.

On the Irritability and Irregular Actions of the Muscles of the Eye.

After what has been said respecting the iris, and the muscle of the crystalline lens employed in adjusting the eye, the following consequences attendant upon irregularity in the actions of the iris, and of the straight muscles, will be readily understood.

The first case of this kind I shall mention contains many curious circumstances. A gentleman never able to bear much muscular exertion, and short-sighted from his infancy, had very good sight till nineteen. He lived at that time in a chalk-country; the glare to his eyes was very great; his amusement was drawing, both in daylight and at night. Under these circumstances strong light became painful, and

he could not fix his eyes on near objects; for eight years a lowering system was employed without benefit.

The next five years, in which nothing was done, the symptoms became stationary. At this period anxiety from misfortunes increased the symptoms, but on recovering from his distress his eyes returned to the same state as before. In this condition I saw him in 1795, when forty-five years of age. There was no external appearance of disease. He could look at objects at some distance, but any attempt to adjust the eye to near distances, gave so much pain as made him desist from both writing and reading.

The iris being intended to regulate the light admitted into the eye, while looking at objects at different distances, it is obvious that the aperture varying incessantly, no distinct outline could be seen, and all objects must appear confused.

Nothing is so commonly met with as muscles from fatigue becoming irregular in their action; and when once this happens, it is difficult, if not impossible, to render the actions of such muscles regular.

I shall give three very remarkable instances of this, in muscles of a very different description.

1st. A gentleman of an irritable habit, wishing to send some secret dispatches to England from Madras, continued writing incessantly for a great many hours, day and night, and probably his arm was chilled by the night-air: the first effect was stiffness, but afterwards, on attempting to write, a nervous pain came upon the muscles of the fore-arm, and became so severe that he was obliged to desist. The symptoms were aggravated by electricity: they never went

entirely off, although the common uses of these muscles gave no pain.

2d. A gentleman, forty-six years of age, after dealing cards all night at a pharo-table, went to bed at four in the morning, the weather sultry, with his curtains and windows open: the wind changed to the north, with rain, which blew directly on his bed, and the right arm lay exposed above the bed-clothes. When he got up, his arm was stiff. Afterwards the rotator muscle of the radius, and muscles of the thumb, became so painful, that the surgeon considered them paralyzed. Upon investigating the case, I found the complaint produced by the fatigue of these muscles, from which they never entirely recovered.

3d. The keeper of one of the first taverns in London, who was proud of the superior excellency of his claret, to show how well it was corked, always drew the corks himself. He consulted me on account of violent nervous pain in the arm, which proved to be the effect of the supinator radii brevis having been strained in that action: he was obliged to discontinue this feat of dexterity.

As distinct vision with two eyes is produced by the image falling upon corresponding portions of the retina, so when one lens is removed, double vision is a consequence.

Why double vision should be produced requires some explanation. It does not arise from the absence of the lens, as that does not alter the situation of the image; and two images of different dimensions, on similar parts of the retina, would appear one before the other; but the cornea will be rendered flatter, and give a different direction to the

pencils of rays, so as to form an image on a part of the retina, not corresponding with that of the other eye.

When the lens is extracted from both eyes, and a convex glass applied to one eye, the object will be double; but if the convex glass is moved about, there will be one situation in which the object will be single, for then the centre of the convex glass is in the axis of vision. These observations are the result of experiments made on the eyes of a lady who had the lens extracted from both eyes.

A similar change in the place of the object on the retina is produced by the straight muscles not corresponding in their action.

Cases of this kind are so often mistaken by medical practitioners, as to make an explanation of their real nature, not simply a matter of philosophical research, but of serious import to the interests of humanity.

The first case of this kind I met with, was in a gentleman shooting moor-game in Scotland. He was much surprized on the evening, after a fatiguing day's sport, to see all at once his horse, dog, and gun double. He was so alarmed, that he gave the horse the reins, least he should take the wrong road, for that was double also. Next morning this had nearly gone off, but on returning to the moors, came back in a greater degree.

He consulted the late Dr. Monro of Edinburgh: it was treated as a disease in the eye-ball; every thing, however, that was done produced no benefit, but aggravated the symptoms.

In despair, he gave up medicine, and lived as usual. All this time the eye was clear; near objects were single; they

began to double at three yards; the two objects separated more and more as the distance increased. A by-stander perceived readily that the two eyes were not equally directed to the object. He was worse on getting up, and better after dinner; in a twelvemonth it went off. The patient mentioned the circumstances to me; and there was no doubt, on considering the case, that the effect arose from the muscles of the two eyes not acting together. The patient had no return; but about six years after lost the use of the muscles of the lower extremities, so as to be unable to walk alone.

I had an opportunity of confirming my opinion of this disease, in a patient under my care in St. George's Hospital. He was a house-painter; his muscles therefore were more likely to be debilitated. He saw double after a fever: I treated him as having a wrong action in the muscles, and confined one eye from light; but looking at objects with the other brought on pain and head-ache, so that I had confined the eye with the weak muscles; I therefore changed the bandage to the other. He no longer had pain, nor inconvenience.

The eye was kept from light for seven days, in a state of perfect rest, and the bandage was then removed to see the degree of advantage that had been derived from rest. The double vision was entirely gone; and although the weak eye was left uncovered, there was no return of the complaint.

On Squinting.

Whenever the motions of the two eyes differ from one another, whether in a less degree, so as to produce double vision, or in a greater, turning one eye entirely from the object, the disease has been called squinting. What I mean at present to consider under this head, is, where the deviation of one of the eyes from the axis of vision is greater than that by which objects are made to appear double; so that in this view, double vision is an intermediate state between distinct vision with both eyes, and squinting.

Squinting has been very generally believed to arise entirely from an inability in the muscles to direct the eye properly to the object.

There is, however, probably no original defect in the muscles; certainly none sufficient to sanction such an opinion; since the muscles of a squinting eye have the power of giving it any direction, but cannot do it without some degree of effort. The defect, therefore, appears to be principally in one of the eyes, which is too imperfect to produce distinct vision.

From this imperfection, the muscles have not the same guide to direct them as those of the other eye; and, therefore, although perfectly formed, their actions, and the others, do not correspond.

In a squinting person, both eyes certainly do not see the object looked at. This is evident to a by-stander, who is able to determine, that the direction of one of the eyes differs so much from the other, as to make it impossible for

the rays of light from any object to fall upon the retina of both; and, therefore, that one eye does not see the object.

The circumstance of those who squint having an imperfect eye, is corroborated by the well-authenticated observation made upon persons who have a confirmed squint, that one of the eyes is too imperfect to see distinctly.

From these observations it would be natural to suppose, that the loss of sight in one eye should produce the appearance of squinting, which is by no means the case; for when that happens, the motions of the two eyes continue to correspond, although not exactly: but the deviation is not equal to what is met with in squinting; it is nearer to that which occurs in double vision.

The reason why the imperfect eye of a squinting person is directed from the object, while a blind one in its motions follows the other, is, probably, the indistinct vision of the imperfect eye preventing the muscles from directing it to the object with accuracy; and this small deviation from the axis of vision renders the object double, and confuses the vision of the perfect eye: to get rid of this confused image the muscles acquire a habit of neglecting to use the imperfect eye. It may also happen that the eye is so imperfect as not to receive a correct image of any object, and may have been neglected from the beginning. Distinct vision being once obtained by the perfect eye, the end is answered, and the mind is never afterwards led to employ the other.

The direction the eye takes under either of these circumstances is inwards, towards the nose, the adductor muscle

being stronger, shorter, and its course more in a straight line than any of the other muscles of the eye.

That the eye, when not accurately directed to the object, produces confused vision, and is for that reason turned away, appears to be confirmed by the case of a patient twenty-two years of age, from whom I had extracted the crystalline lens, while the other eye was perfect. This man, at first, saw objects double, in a manner which extremely distressed him; but, after some months, acquired the habit of neglecting to employ the imperfect eye, and no longer found any inconvenience.

The different degrees of squinting appear to be in proportion to the imperfection in the vision of the eye; and, in some instances, the person is capable of seeing distant objects with both eyes, and only squints when looking at near ones.

The following case is of this kind.

A young lady, twenty-three years of age, had been observed to squint from her infancy; this had not been considered by her friends as the consequence of any defect in her eyes, but as arising from the cradle in which she lay having been so situated, with respect to the light, as to make it attract her notice in one particular direction, so much so as to occasion a cast in one eye. Her eyes are apparently both perfect: when she looks with attention at an object some yards distant, she has no squint; but if her eyes are not engaged by any object, or a very near one, she squints to a considerable degree.

Upon being asked if she saw objects distinctly with both eyes, she said, certainly, but that one was stronger than the

other. To ascertain the truth of this, I covered the strong eye, and gave her a book to read; to her astonishment she found she could not distinguish a letter, or any other near object. More distant objects she could see, but not distinctly. When she looked at a bunch of small keys in the door of a book-case, about twelve feet from her, she could see the bunch of keys, but could not tell how many there were.

To see how far the two eyes had the same focus, she was desired to look at an object in the field of a microscope, and it was found, that she saw most distinctly with both eyes at the same focal distance, although the object was considerably more distinct to the perfect eye than to the other; so that the focuses of the two eyes were the same.

I desired her to cover the perfect eye, and endeavour to acquire an adjustment of the other to near objects, by practising the use of that alone.

At first she was unable to see at all with the imperfect eye; but in some weeks she has improved so much, as to be able to work at her needle with it. This she cannot do long at any one time, the eye being soon fatigued and requiring rest, though without giving pain. She is unable to read with the imperfect eye. These trials have only been made in the course of two months, for a few hours in the day; and her friends think that she squints less frequently than she did.

In this case, it is probable that the imperfect eye never had acquired the power of adjustment to near objects; for as distinct vision seems necessary to direct the muscles in their actions, the perfect eye would require less practice to

adjust itself than the other; and as soon as the near object became distinct to one eye, no information being conveyed to the mind of the failure in the other, all efforts to render its adjustment perfect would be at an end, and it would ever after be neglected while the perfect eye was in use.

Squinting, according to these observations, appears to arise from the vision in one eye being obscure. It may, however, be acquired in a degree by children, who have the lenses of their eyes of different focuses; or have one eye less perfect in its vision than the other; or living constantly with those who do squint, and, by imitation, acquiring a habit of neglecting to use one eye.

The power of squinting voluntarily may also be acquired at any age. This we find to be true, in persons who look much through telescopes: they are led to apply the mind entirely to one eye, not seeing at all with the other. In this case, the neglected eye will at first, from habit, follow the other; but in time, if frequently neglected, may lose this restraint, and be moved in another direction. Some astronomers, whose eyes have been much used in this way, are said to be able to squint at pleasure.

From this view of squinting, it takes place under the three following circumstances: Where one eye has only an indistinct vision; where both eyes are capable of seeing objects, but the one less perfect in itself than the other; and where the muscles of one eye have acquired, from practice, a power of moving it independently of the other.

Where squinting arises from an absolute imperfection in the eye, there can be no cure.

Where it arises from weakness only in the sight of one

eye, it may, in some instances, be got the better of; but to effect the cure, there is only one mode, which is that of confining the person to the use of the weak eye, by covering the other. In this way the muscles, from constant use, will become perfect in the habit of directing the eye upon the object, gain strength in that action, and acquire a power of steadying the eye. When these are established in a sufficient degree, the other eye may be set at liberty.

The time that will be necessary for the cure must depend upon the degree of weakness of the sight, and length of time the muscles have been left to themselves; for it is with difficulty they acquire an increased degree of action, after having been long habituated to a more limited contraction. Looking through the kaleidoscope may be usefully applied to the cure of squinting.

On the Cause of the Illumination in the Cat's Eye.

On this subject there were two opinions; one, that the external light only is reflected, the other, that light is generated in the eye.

Professor Bohn, at Leipsic, made experiments which proved that when the external light is wholly excluded none can be seen in the cat's eye.

The truth of the results was readily ascertained; it therefore only remained to determine whether the external light is, of itself, capable of producing so great a degree of illumination: this was attended with difficulty; for when the apartment is darkened, and nothing but the light from the cat's eye seen, the animal, by change of posture, may

immediately deprive the observer of all light from that source.

This was found to be the case, whether the cat, the tyger, or hyena was the subject of the experiment. On the other hand, when the light in the room is sufficient for the animal to be seen, the light in the eye is obscured, and appears to arise from the iris.

As these difficulties occurred in making experiments on the living eye, others were made immediately after death.

It was found that a strong light thrown upon the cornea illuminated the eye, as in the living animal, but when the cornea was removed this illumination disappeared. The iris was then dissected off, and the tapetum lucidum completely exposed to view, the reflection from which was extremely bright; the retina proving no obstruction to the rays of light, but appearing equally transparent with the lens, and vitreous humour.

These experiments prove that no light is generated in the eye, the illumination being wholly produced by the external rays of light collected in the concave bright coloured surface of the tapetum, after having been concentrated by the cornea and crystalline lens, and then reflected through the pupil. When the iris is completely open, the light is the greatest, but when the iris is contracted, which it always is in proportion to the quantity of external light, the illumination is more obscure, and appears to come from the iris; a part of the light being thrown back upon the iris from the concave surface of the cornea, giving it a striking appearance.

The influence the animal has over this luminous appear-

ance, depends on the action of the iris: when it is shut, no light is seen; when the cat is alarmed, the eye glares, the iris being opened.

On the Orifice Between the Eye and the Nostril in the Rattle-Snake, also in the Deer Tribe.

These orifices lead to a distinct bag of a rounded form, surrounded by a bony cup, formed by the bones of the skull and those of the upper jaw: it is formed in the same manner as the orbit, which it very much resembles.*

The cavities, in their size, bear a relative proportion to that of the snake: they are lined with a cuticle, which is shed with the general cuticular covering, and in this state they are most distinctly seen.

In the deer and antelope there are cavities in the same relative situation, imbedded also in a bony case, and vary in size in different species of these animals.

The French call them larmiers, believing them receptacles for the tears, of which the thinner part evaporating, a substance remains called larmes de cerf.

My friend, Mr. Andre, while residing with the Earl of Egremont, at Petworth, informed me that in the deer these bags are lined with a cuticle: their internal surface is smooth, free from hair, with no appearance of glandular structure.

There is a kind of gutter from the inner angle of the eye to this bag, the skin of which is darker, and the hair shorter, than on the common skin of the animal. The substance contained in the bags resembled that found in the ears.

* Plate XCVI.

In the deer the lacrymal gland is very large; the puncta admit the rounded end of a common probe; there is no lacrymal sac; the tubes from the puncta unite, and pass through a small opening in the bone to the nose.

The following account of these bags in the antelope was sent by my friend, Mr. Bell, from Sumatra, in 1792. The external orifice is the size of a crow-quill: it leads into a bag not larger than a small marble, which has a cuticular lining with hair. From this bag there is a secretion of a limpid fluid, which keeps oozing down the nose.

There are several specimens of these bags in the Hunterian collection, from the Egyptian antelope with annulated horns and other species. In these the internal cavity of the bag is shown, and the structure of the gland behind it: the glandular structure is one-fourth of an inch thick, from which an excretory duct opens into the cavity immediately opposite the orifice. These bags having a secretion of their own, it is probably to defend the skin from the rays of the sun, when exposed to it.

In the snake there is an oval cavity between the bag and the eye, the opening into which is within the inner angle of the eye-lid, directed towards the cornea. In this opening there are two rows of projections, which appear to form an orifice capable of contraction and relaxation. These appear to be reservoirs for a fluid to wash the cornea, and may be supplied by dew shaken off as the snake passes through the grass.

Observations on the Eyes of Fishes.

The eye of the squalus maximus is small for the size of the fish: the eye-ball has projections on the sclerotic coat, to

which the muscles are attached, making it appear quadrangular, but its internal cavity is globular.

The circumference, in the widest part, is nine inches, the longest diameter, three inches, the shortest, one and three quarters. The sclerotic coat is cartilaginous, one-fourth of an inch thick on the posterior part, becoming thinner towards the ciliary processes, where it is only one-sixteenth of an inch.

The cornea is thin, made up of three distinct layers. The middle one much the thinnest.

The optic nerve is about the size of the sixth pair in the human eye: having perforated the sclerotic coat, it projects a little before it gives off the retina, which is extremely thin.

The choroid coat is covered with a tapetum lucidum, the colour of an amalgam of silver broken down, but this might have happened after death. There are ciliary processes: they are slightly prominent, one-third of an inch in extent, and lined with a black pigment.

The vitreous humour is unattached to the choroid coat: its parts are enclosed in strong membranous cells; and the crystalline lens, which is spherical, is imbedded in it for two-thirds of its substance. In the tetrodon mola, called the sun-fish, the vitreous humour has a firm attachment to a groove in the choroid coat, one-twelfth of an inch in breadth, extending from the entrance of the optic nerve to the termination of the retina, in the shortest line from the one to the other, and there are no ciliary processes. Two such remarkable differences in eyes of nearly the same size, belonging to basking fishes, appeared deserving of notice, although not easily explained

The cartilaginous crutch, on which the eye-ball rests, is attached to the bottom of the orbit, is seven and a half inches long: its stem is flattened, and terminates in a broad concave surface; in a transverse direction, adapted to the bottom of the eye-ball, it has a ligament admitting of motion on the orbit.

There are four straight muscles and two oblique; the straight ones larger than can be required to move so small an eye; the rectus externus and internus strongest: they are five inches in circumference, while the superior and inferior are only three and a half inches.

In the eyes of fishes the ciliary processes are wanting, and the iris does not contract from light.

There is a muscle which Mr. Hunter called the choroid muscle, I believe common to all fishes: it has a tendinous centre round the optic nerve, where it is attached to the sclerotic coat. The muscular fibres are radiating from this tendon. The shape is that of a horse-shoe, anteriorly attached to the choroid coat, and by means of it to the sclerotic: its action must bring the retina forward; and the optic nerve has a bend in it to admit of this motion.

In fishes, it would appear that the eye is adjusted to distant objects, by this choroid muscle bringing the retina nearer to the lens.

LECTURE IX.

On the Organ of Hearing.

Nineteen years ago, I discovered that the membrana tympani in the elephant was composed of muscular fibres, and led on by that discovery, was enabled to show that this membrane in the human ear has a similar structure.

Till that time the membrana tympani was considered as a drum, which is tightened and relaxed by the handle of the malleus being pressed against its centre.

The presence or absence of such pressure being deemed sufficient for bracing or unbracing it, less attention was bestowed on the structure of the membrane itself, which, from the smallness of its size and its confined situation, is with difficulty got at, so as to be accurately examined.

In the elephant, its size is so much larger than in other animals, that muscular fibres can be seen with the naked eye, passing along the membrane in a radiated manner, from the bony rim which surrounds it to the middle part of the circle, where it is connected to the handle of the malleus.

Before I proceed further upon the subject of this dis-

covery, by explaining the uses to which it may be applied in tuning the ear to different sounds, it may not be improper to give some account of the circumstances by which I was first led to engage in this investigation.

Three different opportunities had occurred in London of dissecting elephants; the first of these happened at the time I began to study Comparative Anatomy: the animal had been presented to the king, by Sir Robert Barker on his return from India, and was very young; the other two were nearly full grown: they died at different periods at Pimlico: one was given to the late Dr. Hunter; one to his brother, the late Mr. John Hunter; and the third, to Sir Ashton Lever.

From my being connected with Mr. John Hunter's pursuits in Comparative Anatomy, I was employed throughout the whole of these dissections, and became extremely desirous of examining the internal parts of the ear, the structure of that organ in the human body having at a very early period particularly engaged my attention*; but neither Dr. Hunter nor his brother could be prevailed upon to sacrifice so large a portion of the skull for this purpose.

When Mr. Corse arrived from Bengal, and mentioned his having brought over a number of skulls of elephants, in

* In the year 1776, I injected the cochlea and semicircular canals of the human ear, with a composition of wax and resin. This was done by placing the temporal bone in the receiver of an air-pump; the upper part of which was in the form of a funnel, rendered air-tight by a cork being fitted into its neck, and surrounded with bees' wax. After the air had been exhausted, the hot injection, poured into the funnel, melted the wax, and the cork was pulled out by a string previously attached to it: the injection immediately rushed into the receiver, and was forced, by the pressure of the atmosphere, into the cavities of the temporal bone.

order to show the progress of the formation of their grinding teeth*, the desire to examine the organ of hearing in that animal recurred to me so strongly that I requested to have one of the skulls for that purpose, and Mr. Corse very readily and obligingly complied with my request.

After having examined the organ in the dried skull, the want of the membrana tympani and of the small bones made the information thus received of a very unsatisfactory nature, and increased the desire of seeing these parts in a recent state. In considering how this could be done, I recollected a small mutilated elephant's head, preserved in spirit, which had been sent to Mr. Hunter, but, from the multiplicity of his engagements, had remained neglected in the cask at the time of his death, and in the following year was dried, to show the proboscis, that it might not be altogether lost.

Upon examining this dried head, the bones had been so much broken, that one of the organs of hearing was altogether wanting; the other, however, was fortunately entire; and the membrana tympani and small bones, although disturbed in the drying of the parts, still remained, but the handle of the malleus had been broken.

The membrana tympani, and every other part of the organ, were found to be much larger in proportion than in other quadrupeds, or in man; differing in this respect from the eye, which is unusually small, when compared with the enormous bulk of the animal.

* On this subject, a very ingenious paper of his has been published in the Philosophical Transactions for the year 1799.

The membrane was found of an oval form; the short diameter of the oval rather more than an inch and seven-twentieths.

In the human ear, the membrana tympani is nearly circular: the longest diameter is eight-twentieths of an inch; the shortest, seven-twentieths.

As the membrane in the elephant exceeds that of the human ear in thickness as much as in extent, which is as the squares of their diameters, or in proportion of one hundred and thirty five to fourteen, it is natural to conclude that the muscular fibres which are to tighten the one must greatly exceed in strength those capable of producing the same degree of tension in the other.

From this statement, the muscular structure in the human membrana tympani will necessarily be so much less distinct than in the elephant, as scarcely to be visible to the naked eye, and will easily be overlooked by the most attentive observer, who is not directed by some previous information to examine it under the most favourable circumstances; but, when these are attended to, it can be perceived without the aid of glasses.

If the membrana tympani of the human ear is completely exposed on both sides, by removing the contiguous parts, and the cuticular covering is carefully washed off from its external surface, then, by placing it in a clear light, the radiated direction of its fibres may be easily detected. If a common magnifying-glass is used, they are rendered nearly as distinct as those of the elephant appear to the naked eye: their course is that of the radii of a circle of equal lengths, passing from the circumference to the centre.

When viewed in a microscope, magnified twenty-three times, the muscular fibres are beautifully conspicuous, and appear uniformly the same throughout the whole surface, there being no central tendons, as in the diaphragm: the muscular fibres appear only to form the internal layer of the membrane, and are most distinctly seen when viewed on that side.

In examining this membrane in different subjects, the parts were frequently found in a more or less morbid state. In one instance, the membrane was found loaded with blood-vessels, was less transparent than usual, and was united by close adhesion to the point of the long process of the incus.

In another instance, there was a preternatural ossification adhering to it, at a small distance from the end of the handle of the malleus.

As muscles in general are supplied with blood-vessels, in proportion to the frequency of their action, it became an object of importance to determine the vascularity of the membrana tympani. The vessels in their distribution resemble those of the iris, and are nearly half as numerous: they anastomose with one another: their general direction is from the circumference to the handle of the malleus: from near the handle a small trunk sends off branches in a radiated manner, which anastomose with those that have an opposite course.*

This correspondence, in the number and distribution of blood-vessels, between the membrana tympani and iris, is a

* Plate XCVII.

strong circumstance in confirmation of the membrana tympani being endowed with muscular action.

In the horse, the membrana tympani is smaller than in man: its long diameter is eight-twentieths of an inch; the short one six-twentieths; and it is almost quite flat, while in man it is concave, which makes the difference of extent considerably exceed the difference in the diameters. In the horse, the fibrous structure is not visible to the naked eye; it is even indistinctly seen, when viewed through a common magnifying-glass; but in a microscope it is very visible, and agrees in structure with the membrane in the human ear, and in that of the elephant.

In birds, the membrana tympani is larger in proportion than in the quadruped, and more circular in its shape.

In the goose, it is six-twentieths of an inch in its longest, and five-twentieths in its shortest diameter.

In the turkey, seven-twentieths by five-twentieths.

It is thinner in its coats in birds than in the horse, and to the naked eye has no appearance of fibres; but, when viewed in a microscope, there is a visible radiated structure, not very unlike the wire-marks upon common writing paper.

In birds, where from the smallness of its size the resistance is very trifling, the membrane is very similar to the coat of an hydatid, only still thinner. In the elephant, fibres forming fasciculi are very distinct. The membrane of the horse, and that of the human ear, form the intermediate gradations.

The knowledge of a muscular structure in the membrana tympani enables us to explain many phenomena in hearing,

which have not hitherto been accounted for in a satisfactory manner. It is principally by means of this muscle that accurate perceptions of sound are communicated to the internal organ, and that the membrana tympani is enabled to vary the state of its tension, so as to receive them in the quick succession in which they are conveyed to it.

In the human ear, and in that of birds, the radiated fibres of the membrana tympani have their principal attachment to the extremity of the handle of the malleus, which is nearly in the centre of the membrane.

In the membrane of the elephant, which is oval, the attachment to the handle of the malleus is at some distance from the centre. In the horse, deer, and cat, which have the membrane still more oval than the elephant, the handle of the malleus is situated in the long axis of the membrane, with its extremity extending beyond the centre, reaching near to the circumference; and the fibres of the radiated muscle are not only attached to its end, but also laterally to nearly the whole length of its handle.

The organ of hearing in the ornithorhynchus, the dugong, and whale-tribe, differ in many respects from those of land-animals in general.

In the ornithorhynchus paradoxus, the external ear is an oval slit one inch long, larger than the openings of the eye-lids; the orifice of the tube very small, but soon enlarging and passing some way under the skin before it reaches the organ.

The membrana tympani is larger than in quadrupeds of the same size, is oval, the central part drawn in, making the external surface concave. There are only two bones, one

passing directly from the membrana tympani towards the foramen ovale; the second, resembling imperfectly the stapes, having a flat surface of a circular form on the orifice of the foramen ovale, and a narrow neck connecting it to the other. This mechanism is an approach to the bird.

In the ornithorhynchus hystrix, the external opening of the ear is large enough to admit the end of the finger; the meatus takes the same sweep as in the paradoxus: just before it reaches the membrana tympani, it contracts to the size of a crow-quill, then again dilates, forming a cavity in the front of the membrana tympani: the canal, till it arrives at this contraction, has a cuticular lining with hair.

The membrana tympani is extremely concave, and is covered by a cuticle: it is of an oval form, the long axis four-twentieths, the short, three-twentieths of an inch: its centre is attached to a small bone connected with the rim, on which the membrane is supported: this bone corresponds with the malleus in the quadruped; within, and united to this, is a small bone in the form of a trumpet, corresponding to the stapes, as it fills the opening of the foramen ovale.

There is no perfect cochlea as in the quadruped, but an imperfect one, consisting of a conical cavity, a little bent: in the middle, there is a double cartilaginous septum; the two lamina of which unite before they reach the top of the cone; by this means, the surrounding cavity becomes a spiral canal, one end of which opens into the vestibulum, the other terminates at the foramen rotundum, as in the bird.

In examining the organ of hearing in the dugong, which was done with more facility, as the skull had not been completely formed, I met with a peculiarity that does not belong,

as far as I am aware of, to any other tribe of animals. The malleus and incus, which have nearly the same shape as in other animals, are fastened to the sides of the tympanum by a bony substance extending across the intervening space. The malleus is in this way connected to one side of the tympanum, the incus to the other, so as to render these ossicula in a great measure immoveable.

The nearest approach to this mechanism is a bony attachment of the malleus to one side of the tympanum, which Mr. Hunter states he had met with in some of the whale-tribe; but does not mention in what species. He says, not the balæna mysticetus; so that this structure does not belong to those genera that live principally upon the surface, nor to those that penetrate the unfathomable depths; and as he describes at length the organ in the pike-whale, without mentioning this peculiarity as part of the description, it could not have occurred in that species. This renders it probable that he met with it in the grampus, or the bottle-nose; and it is very likely in both, as he insinuates that it is not confined to one species.

The stapes is unconnected with the foramen ovale, to which it is opposed; nor is it anchylosed with the ramus of the incus.

The handle of the malleus projects in the centre of the circle, over which the membrana tympani had been spread, so as to leave no doubt that, in the living animal, it is attached to the centre of that membrane.

The dugong feeds on the plants that grow at the bottom of the sea, and comes in great numbers to the harbours of uninhabited islands, and remains for many hours in the

shoal water, where it finds food: at least, this account is given of its habits by Mr. Leguat, who, with several companions, spent nearly three years in an island previously uninhabited, about fifty leagues from the Mauritius, — and the dugong was a principal part of their food.

It is from him we learn that their usual length is twenty feet; but that catching them full-grown was a service of danger; nor were the large ones delicate food for the table.

This account was published in 1720, and is written with so much apparent candour, that there is no reason for doubting the veracity of the narrative.

As these habits are allied to those of the hippopotamus, I enquired whether this peculiarity of structure exists in the ear of that animal, but find there is nothing of the kind; all the ossicula are separate, and very readily drop out of the cavity of the tympanum, when the skull is deprived of the soft parts. There are peculiarities in the mechanism of this organ in the hippopotamus which deserve being mentioned. The projecting ear and meatus auditorius externus have a higher situation upon the head than in most other animals; and the tube that passes down to the membrana tympani is one straight line.

The bony portion of it is four inches long: its direction from the external surface of the head down to the membrane is at an angle of 45°, and its termination is upon a ledge, which forms a slight projection beyond the bony ring, to which the membrana tympani is attached: the space on the outer surface of the membrane, between it and the opposite side of the tube, is so small, that it cannot exceed the thickness of the membrane itself. The ossicula are small, when the

size of the animal is considered; but the cochlea makes two turns and a half, which is by no means common: the semi-circular canals have the usual appearance.

This animal, I understand from every enquiry I have been able to make, when it goes down into the water to feed at the bottom, allows itself to sink by its own weight, descending in a standing posture, so that as soon as the head is covered, the water would pass into the tube of the ears, were there not something like a valve at the orifice of the meatus externus to prevent it. In other animals that live in the sea, or are much under water, there are contrivances very different from this, to prevent the water *getting into the* tube of the ear. In the whale-tribe the external orifice is so extremely small, as to exclude water. In the seal, the meatus externus makes a turn nearly circular, to answer the same purpose. In the ornithorhyncus paradoxus, the external opening is at a great distance from the organ; and the meatus, which is the size of a crow-quill, and cartilaginous, winds round upon the temporal bone. The external meatus in the walrus is a round orifice without any projecting external ear; the orifice in the bony tube corresponds in size with that of the hippopotamus; its termination at the membrana tympani is less oblique, and its direction horizontal. The ossicula in the hippopotamus are small, the stapes is imperforate, and the bones have no bony union.

The external orifice of the meatus externus in the dugong is extremely small, so as readily to exclude the water. The cochlea is very small, making only one turn and nearly one half.

The semicircular canals are also exceedingly small. The peculiar bony connections to the tympanum, connecting the malleus and incus with the bones of the skull already described, lead to the idea that this animal is more indebted for its hearing, than any other that lives in water, to the vibrations received by the bones of the skull being communicated through the bony connections that have been mentioned to the ossicula, and from thence to the cochlea and semicircular canals.

In the manatee the organ of hearing is the same exactly as in the dugong.

I have for a long time been desirous of an opportunity of examining the membrana tympani in the balæna mysticetus, having no doubt of its being of such extent as to show the structure to advantage; and by the kind attention of Mr. Scoresby, junior, of Whitby, I have now succeeded. That gentleman, in a voyage in the Greenland whale-fishery, procured for me the cranium of a cub of the balæna mysticetus, whose extreme length was from sixteen to seventeen feet, and its circumference from twelve to thirteen feet.*

This cranium was put into a cask of salt water, and arrived in London in good condition, the different parts of the organ of hearing being in a state fitted for dissection.

In my examination of the organ of hearing in this young whale, I find there is a peculiarity in its mechanism not met with in the smaller species of whale, and to which there is nothing similar in other animals. As this very singular mechanism is not noticed by either Camper or Monro, and is only glanced at by Hunter, to whom it was imperfectly

* Plates C. CI.

known, I shall give a description of it; and in doing so, mention the other parts of the organ, so far as will be necessary to make myself understood.

The cranium had been deprived of the external skin, consequently the outward aperture of the ear had been removed.

I have since learnt from Scoresby, who has had an opportunity of examining roughly at sea the external meatus of a larger whale, that he found in the middle of the soft external meatus a projection in one side of the tube, and a corresponding concavity in the other, and by applying these together the canal was completely closed. This valvular apparatus unfortunately had been cut off in the specimen I examined.

The tube was one quarter of an inch in diameter, in the mutilated specimen at the cut end; in the middle it was narrower, and near the membrana tympani one inch and one-third of an inch.

By comparing the measurement of the length of the tube with that of the skull in this whale, and with the large skull in the Hunterian Museum, the meatus externus in the full-grown whale will be found to be about two feet six inches in length.

The membrana tympani is one inch and one-tenth of an inch in diameter, where it is attached to the bone: instead of being concave, as in other animals, towards the meatus externus, it is convex, and projects nearly an inch into that tube. Its external surface is composed of a smooth, firm, cuticular covering, which readily separates as soon as putrefaction comes on: under this is a strong compact

membrane; and when that is removed, there is a regular layer of muscular fibres; these go over the whole of the embossed part, having their origin at the edge of the bone to which the membrane is attached, and terminating in the bone on the opposite side. This arrangement of muscular fibres differs from that of the elephant, where the central part is tendinous.

The muscular fibres have a membranous lining between them and the cavity of the tympanum.

From this description of the membrana tympani, it is evident that there is no connexion between it and the ossicula auditus, or small bones of the ear, which Mr. Hunter supposed to be the case, in consequence of having found that it was so in the porpoise.* He says, "In the piked whale the "membrana tympani is projecting, and returns back into "the meatus externus for above an inch in length, is firm "in texture, with thick coats, is hollow on the inside, and its "mouth communicating with the tympanum, one side being "fixed to the malleus, similar to the tendinous process "which goes from the inside of the membrana tympani in "the others."

Tbe fact is, that there is no connexion whatever between the membrana tympani and the malleus, as will be explained; but as that circumstance forms the great peculiarity in the organ of this species of whale, I thought it right to quote what he had stated on this subject.

Having pointed out that there is no direct connexion between the membrana tympani and the ossicula auditus, as

* Observations on the Structure and Œconomy of Whales. Philosophical Transactions, Vol. lxxvii. p. 371.

in other animals, and also shown that Hunter, unwilling to believe that there could be so great a deviation from the ordinary construction of this organ, was led into an error, which I can only attribute to his having formed to himself too strong a chain of analogies, I shall proceed in my description of the organ.

Immediately behind the membrana tympani is a large cavity, formed principally by the concave surface of a large hard bone peculiar to the whale, in the substance of which there is more earthy matter than in almost any other bone met with in animal bodies. In its form, it is not very unlike the shell called the concha veneris, to which it has been compared.

The cavity of the tympanum is of an oval shape, one end of which is bounded by the membrana tympani, the other forms the Eustachian tube; and there the cavity is surrounded wholly by membrane inclosed in the substance of the skull.

The large concave bone is only slightly connected with the petrous portion of the temporal bone, and is imbedded in a fatty substance of nearly an inch in thickness, with a smooth external surface.

The Eustachian tube is two inches and a half long; it opens externally into the canal leading to the blow-hole; its internal surface is honey-combed, which gives it a glandular appearance; and there are chords and septa crossing from side to side in different places; where it opens into the cavity, it has a vascular structure. The cavity, as it corresponds in its principal uses with the tympanum of other animals, although it does not, as in them, contain the ossicula auditus, deserves to be called by the same name; it is equal

in size to a pint measure, and can only be filled from the Eustachian tube, there being no other opening by which it can communicate externally.

Within the cavity of the tympanum, close to the bony rim to which the membrana tympani is attached, there is a membranous fold, fixed at one end to the centre of a slight protuberance on the concave surface of the large hollow bone, and stretched across the cavity, its loose upper edge forming a line across the centre of the hollow of the membrana tympani, the other end passing beyond the cavity, to be attached to the short handle of the malleus, which is situated immediately behind the membranous lining of the tympanum.

The long handle of the malleus is left loose.

The incus and stapes have the same relative situation to one another as in the human ear, differing in nothing, but being contained in a cavity distinct from that of the tympanum.

The os orbiculare is wanting.

The other parts of the organ, the vestibulum, semicircular canals, and cochlea, and the meatus internus, through which the nerves from the brain pass to be distributed to these parts, do not differ materially from what is met with in the human ear.

From the mechanism which has been described, it is evident that the impulses made on the membrana tympani are not immediately communicated to the ossicula auditus as in other animals; they are only communicated to the tympanum, and thence to the chord stretched across the cavity.

The membrana tympani, by its muscular structure, has within itself the means of adjustment to different sounds, while the animal is under water; but the degree of pressure to which it is liable is incompatible with the nicer vibrations required to impress the internal organ, so as to convey to it distinct sounds; and it is for this last purpose that the membrane is stretched across the cavity of the tympanum.

This membrane, from being connected with the concave bone, will have its vibrations increased; and the bone being imbedded in a fatty covering, none of the vibratory motion impressed upon it can be carried off from the opposite side, but the whole will be communicated to the malleus, and so on to the cochlea and semi-circular canals.

The oval form of the membrana tympani in quadrupeds, and the very extensive attachment of the fibres of the radiated muscle to the handle of the malleus, may be the reason why their ears are not equally fitted to hear inarticulate sounds, as the ears of birds and man.

Should this radiated muscle of the membrana tympani, (which is one of the smallest in the body that has a distinct action,) be thought too insignificant to have an office of so much consequence assigned to it, let it be remembered, that the size of muscles is no indication of their importance, but only of the resistance to be overcome by their action; and that the more delicate actions are performed universally in the body by very small muscles, of which the iris in the eye, mentioned in the preceding Lecture, forms a very conspicuous example.

Before the mode in which this radiated muscle adapts

the membrana tympani to different sounds can be explained, it is necessary that the important parts of the organ should be enumerated, and the use commonly assigned to each of them pointed out.

In man, and the more perfect quadrupeds, this organ consists of the following parts: the membrana tympani, situated between the external passage and the cavity of the tympanum; four small bones, which form a chain across the tympanum, connecting the membrana tympani with the foramen ovale, which opens into the vestibulum, a more internal part of the organ of hearing.

The bones are, the malleus, which is united to the membrana tympani by a portion of its handle, and to the second bone or incus by its head: the incus, which is connected to the malleus by a capsular ligament, forming a regular joint: the surfaces of the bones being covered with cartilage, have only a tremulous motion on one another. The incus is also attached to the side of the cavity where the mastoid cells open, by a ligament on which it moves backwards and forwards: it is united by its long process to the orbicular bone, which is the smallest in the body, and connects the incus to the fourth bone or stapes, which has its base applied to the foramen ovale, or opening leading into the cavity of the vestibulum.

The cavity of the tympanum, in which these bones are situated, communicates with the external air by means of the Eustachian tube, so that there is always air behind the membrana tympani.

The malleus has three muscles, by which it is moved: one of them is called the tensor, from its pulling the malleus

inwards, and tightening the membrana tympani; the other two act in an opposite direction, and relax the membrane: the largest of these is called the obliquus, and is the antagonist of the tensor muscle; the other is very small, and is called the laxator.

The stapes has one muscle, which acts upon it by bringing its base closer to the foramen ovale.

The vestibulum, which is completely separated from the tympanum by the membrane that lines the foramen ovale, communicates freely with the cochlea and semicircular canals; but these cavities are filled with a watery liquor, and have no communication (as the tympanum has) with the external air.

This fact was ascertained in the horse, by the following experiment, repeated several times.

The organ of hearing was separated from the skull immediately after death, and the cavity of the tympanum exposed; the parts were then immersed in water, and the stapes removed, by which means the membrane of the foramen ovale was destroyed, but no globule of air was seen to escape through the water.

The following uses have generally been assigned to the parts I have just mentioned:

The membrana tympani was supposed to be brought into unison with different vibrations; its degree of tension being varied by the action of the tensor and laxator muscles: these impressions were conducted by the chain of bones to the vestibulum, cochlea, and semicircular canals; in which cavities, particularly the cochlea, they were supposed to

undergo some modification, before they impressed the nerves spread upon the linings of the cavities.

The function of modifying impressions of sound was assigned to the cochlea, partly from there being a delicacy in its internal structure, supposed to resemble a musical instrument, and partly from there being no other portion of the organ apparently suited for repeating the variety of delicate sounds which pass into the ear; the changes that could be produced upon the membrana tympani, by the muscles of the malleus, being considered as incapable of answering that purpose.

This slight sketch of the organ of hearing, and of the uses, as they are generally explained, of the different parts, will enable you to understand with more clearness what parts of the theory appear defective, and what improvements may be made upon it.

It is true that the membrana tympani is stretched and relaxed by the action of the muscles of the malleus, but not for the purpose alleged in the commonly received theory.

It is stretched in order to bring the radiated muscle of the membrane itself into a state capable of acting, and of giving those different degrees of tension to the membrane, which empower it to correspond with the variety of external tremors: when the membrane is relaxed, the radiated muscle cannot act with any effect, and external tremors make less accurate impressions.

The membrana tympani, with its tensor and radiated muscles, may not be unaptly compared to a monochord; of which the membrana tympani is the string; the tensor muscle the screw, giving the necessary tension, to make

the string perform its proper scale of vibrations; and the radiated muscle acting upon the membrane, like the moveable bridge of the monochord, adjusting it to the vibrations required to be produced. The combined effects of the action of these muscles give the perceptions of grave and acute tones; and in proportion as their original information is more or less perfect, so will their actions be, and, consequently, the perceptions of sound which they communicate.

The mode of subdividing the motions of the membrana tympani between two sets of muscles, allotting a portion to each, is not peculiar to this part. A remarkable instance of it appears in the rapid movements of the fingers, in performing several actions, and particularly in playing on a musical instrument.

In all such rapid motions the fingers are bent, to a certain degree, by the long muscles that lie upon the fore-arm, to the tendons of which a set of smaller muscles are attached, called lumbricales. These last are unable to produce any effect on the fingers, till elongated, in consequence of the action of the long muscles in bending the other joints; the lumbricales then become capable of bending the fingers a little more, and of acting with great rapidity.

It is a curious circumstance, that a similar application of muscles should be employed to fit the fingers to produce a quick succession of sounds, and to enable the ear to be impressed by them.

The Countess Lieven,* lady to the Russian ambassador, plays upon the piano-forte with uncommon velocity,

adapting the music to her own voice, in a manner that astonishes her hearers.

Being present in the year 1820, at a concert at the Royal Pavilion, Brighton, I saw at once how this was accomplished; she contracted the long muscles, and by keeping them in that state, played only by using the lumbricales.

From the explanation given of the adjustment of the membrana tympani, the difference between a musical ear and one which is too imperfect to distinguish the different notes in music, will appear to arise entirely from the greater or less nicety with which the muscle of the malleus renders the membrane capable of being truly adjusted. If the tension be perfect, all the variations produced by the action of the radiated muscle will be equally correct, and the ear truly musical; but if the first adjustment is imperfect, although the actions of the radiated muscle may still produce infinite variations, none of them will be correct: the effect in this respect will be similar to that produced by playing upon a musical instrument which is not in tune. The hearing of articulate sounds requires less nicety in the adjustment than of inarticulate or musical ones; an ear may, therefore, be able to perceive the one, although it is not fitted to receive distinct perceptions from the other.

The nicety or correctness of a musical ear being the result of muscular action, renders it, in part, an acquirement: for, although the original formation of these muscles in some ears renders them more capable of arriving at this perfection in their action, early cultivation is still necessary for that purpose; and it is found that an ear, which upon the first trials seemed unfit to receive accurate perceptions of sounds,

shall, by early and constant application, be rendered tolerably correct, but never can attain excellence.

There are organs of hearing in which the parts are so nicely adjusted to one another, as to render them capable of such accuracy in hearing sounds as almost to seem preternatural.

Children, whose organs of hearing are perfect, will learn inarticulate sounds more quickly than articulate ones, for the sounding of which more parts are employed, as the tongue, lips, &c.; and if, during their infancy, they are much in the society of musical performers, will be naturally induced to attend more to musical sounds, and by this means acquire a correct ear, which, had they listened for two or three years to articulate sounds only, would have been attained with more difficulty.

This mode of adapting the ear to different sounds appears to be one of the most beautiful applications of muscles in the body; the mechanism is so simple, and the variety of effects so great.

Young Mozart is a wonderful illustration of what has been asserted, although the observation preceded my knowledge of his history twenty years.

So perfect was the muscular structure of the membrana tympani, and all the other parts of the organ of hearing, that even in his infancy he could attune his ear to the most delicate vibrations of sounds that can be produced. When scarcely three years old, while his father was teaching his elder sister her notes, this astonishing disposition for music manifested itself. Young Mozart was playing upon his little piano-forte, his favourite instrument, and amused

himself by seeking for thirds, and nothing could equal his joy when he had found this harmonious chord. At four years of age, he would learn in half an hour to play a minuet; other more difficult pieces in an hour. At five, he invented pieces of music which his father wrote down. At six, he composed a concerto too difficult for the most skilful performer to do justice to. At seven, he could point out the slightest difference of sound; and every false or even rough note not softened by a chord was torture to his ear. Such was the delicacy of his ear, that till ten he had a horror for the sound of the trumpet: the very sight of it was like putting a pistol to his breast, unless used merely as an accompaniment. His father, to overcome this horror, had the trumpet brought before him, and prepared him for it: on the first blast, he became pale, and fell upon the floor, so that the trial was not repeated.

So accurate was his recollection of sounds, that he asked his friend Schachtmar to send him his violin, tuned as it was at their last meeting, "it was half a quarter of a note below mine." This on sending for the violin was found to be correct.

At eight, he began to cultivate singing airs: this he did with great expression.

When twenty, the most numerous orchestr^a did not prevent him from observing the slightest false note; and he immediately pointed out with surprising precision the note that should have been made, and the instrument that was in fault.

The muscles of the membrana tympani, giving the membrane its proper tension, bear a close analogy to the modes

by which the eye and the voice are adjusted: the one has been explained, and the other is performed by the arytenoide muscles varying the aperture of the glottis, and, when necessary, relaxing the ligaments by which the aperture is formed, so as to admit of the shakes that are produced in singing.

None of these muscles are apparently under the power of the will: the different actions they perform in producing the adjustments required were, in their first acquirement, the result of experiments upon the organ to which they belonged.

The adjustment of the eye was ascertained by its being the most distinct state of vision which had been produced.

That of the ear, by its being the most distinct impression of sounds.

That of the organ of voice, by the correctness of the effect produced upon the ear, and therefore the slightest imperfection in the ear precludes any one from having a musical voice.

A knowledge of the means by which the membrana tympani adjusts itself enables us to understand the different ways in which a musical ear is rendered imperfect, by nervous affections and other causes, of which the following are illustrations.

Case 1. A gentleman, thirty-three years of age, who possessed a very correct ear, so as to be capable of singing in concert, though he had never learned music, was suddenly seized with a giddiness in the head, and a slight degree of numbness in the right side and arm. These feelings went off in a few hours, but on the third day returned; and for

several weeks he had more or less of the same sensations. It was soon discovered that he had lost his musical ear; he could neither sing a note in tune, nor in the smallest degree perceive harmony in the performance of others.

For some time he himself had become a little deaf, but his medical attendant was not sensible of it in conversation. Upon going into the country, he derived great benefit from exercise and sea-bathing.

Twenty months after the first attack, he became capable of singing a Scotch air with tolerable exactness, though he could not sing in concert.

He continued to improve in his health, and in the course of two or three years completely recovered his ear for music.

In this case, there appeared to be some affection of the brain, which had diminished the actions of the tensor muscles of the membrana tympani, through the medium of the nerves which regulate their actions: this gradually went off, and the muscles recovered their former action.

Case 2. A young lady was seized with a frenzy which lasted for several years.

Previous to her derangement she was incapable of singing in tune, from the want of an ear for music; but in the course of her madness, she frequently, to the astonishment of her relations, sung a tune with tolerable correctness.

This case is the reverse of the former; and as it arose from a directly contrary affection of the brain, may be considered as the result of an unusual degree of action in the tensor muscles, giving the membrane a more correct adjustment than it had before.

Case 3. An eminent music-master, after catching cold, found a confusion of sounds in his ears. Upon strict attention, he discovered, that the pitch of one ear was half a note lower than that of the other; and that the perception of a simple sound did not reach both ears at the same instant, but seemed as two distinct sounds, following each other in quick succession, the last being the lowest and weakest. This complaint distressed him for a long time, but he recovered from it without any medical aid.

In this case, the whole defect appears to have been in the action of the radiated muscle, exerted neither with the same quickness nor force in one ear as in the other, so that the sound was half a note too low, as well as later in being impressed upon the organ.

This affection of the muscles of the membrana tympani is very similar to an affection of the straight muscles of one of the eyes, producing double vision, which I have noticed in a former Lecture, when treating of the wrong actions of that organ.

In endeavouring to explain the uses of the more internal parts of the ear, considerable advantage may be derived from arranging them in two divisions, namely, those which are formed for the purpose of receiving impressions conveyed through the medium of liquid or of solid substances, and those adapted to receive impressions made by the impulses of an elastic fluid, as the common air.

This can be done very correctly.

Fishes, which are formed to hear in water, can have only the parts belonging to the first division; while all the parts

found in the ears of birds and quadrupeds, that are not met with in fishes, must belong to the second.

In fishes, the organ consists of a vestibulum and three semicircular canals; and these are met with in all fishes. In some genera substances of a hard nature are found lying loose in the vestibulum; these, however, cannot be considered as essential parts of the organ, from their not being common to fishes in general.

Birds have the vestibulum and semicircular canals in common with fishes, but they have also a membrana tympani; a slender bone connecting that membrane with the vestibulum, and an Eustachian tube. In birds, the membrana tympani is convex externally, being pushed forwards by the end of the slender bone above mentioned.

This bone having one end pressing upon the centre of the membrana tympani, which is circular, explains their having a musical ear.

In quadrupeds and man, besides the vestibulum and canals met with in fish, the membrana tympani, the bones connecting it with the vestibulum, and the Eustachian tube, found in birds, there is a cochlea. The membrana tympani is either flat or concave externally: the bony connection between it and the vestibulum is made up of several bones, supplied with muscles to move them in different directions.

The parts which compose the organ of hearing in fishes must be intended for receiving impressions conveyed through water: those additional parts met with in birds, and the still greater additions which are found in the quadruped and man, must be intended by nature for rendering

more perfect the impressions conveyed to the organ through the external air.

Fishes, from the structure of the organ, can only hear sounds which agitate the water immediately in contact with the head of the fish; so that the impulse is conveyed without interruption from the liquid in which they live, to the organ of hearing.

Man is capable of hearing in a similar manner to fishes, when a communication of solid parts is kept up between the sounding body and the bones of the skull. Experiments of this kind must have been made by many members of this College.

One of the most common is, applying a watch to the forehead, and stopping the ears, which does not prevent the ticking from being heard: the sound is still more distinct when the watch is applied to the mastoid process. Here, as the sound can neither pass through the meatus externus nor by the Eustachian tube, while the mouth is kept shut, it evidently must be conducted through the bones of the skull.

When the sound produced by boiling water is brought to the ear, by one end of an iron rod resting upon the side of the kettle, and the other kept in contact with the teeth, the sound is conducted in the same way, although in this case it has by some been supposed to pass through the Eustachian tube.

In this mode of hearing, the vestibulum and semicircular canals are probably the only parts of the organ which are necessary to convey the impression to the expansion of the auditory nerve.

In hearing in air, the use of the membrana tympani in man and quadrupeds has already been explained. Its office in birds is precisely the same; but as in birds this membrane has no tensor muscle to vary its adjustment, but is always kept tense by the pressure of the end of the slender bone, this scale in birds cannot descend so low as the human ear; and the intervals in their scale will be more minute, in consequence of the slightest tremor communicated by the action of the radiated muscle, to one end of the slender bone being immediately conducted to the internal organ, while in the human ear it has to pass from one bone to an other before it arrives at the vestibulum.

The cochlea has been considered by physiologists as one of the most intricate and curious parts of the ear; and on that account had a most important office assigned to it.

This, however, is now to be transferred to the membrana tympani; and upon attentive consideration of the subject, it will appear impossible for the cochlea to be of any use in modulating sounds, since the ear is only intended to convey impressions received from external bodies; hence, no impression can be communicated to the cochlea, which has not been transmitted by the membrana tympani.

If all the varieties of sound are repeated by the membrana tympani, no modulation in the cochlea is required; and, when it is considered that the cochlea contains water instead of air, the effect upon every part will be found simultaneous.

That the cochlea is neither absolutely necessary to fit the organ to be impressed by sounds communicated through air,

nor to render it what is termed a musical ear, is sufficiently proved by that part being wanting in birds, whose organ is particularly adapted to inarticulate sounds.

Some birds, particularly bullfinches, can be taught to sing various airs, although it will be always in high notes.

If it should be found that birds hear less accurately than quadrupeds, it will favour the idea that the great delicacy of structure of the cochlea is intended to render the nerves which are spread upon it more readily impressed by weak tremors, than those in either the vestibulum or semicircular canals.

The cochlea and semicircular canals must be considered as two of the most important parts of the ear: their peculiar forms are, no doubt, adapted to some essential purposes; but what the precise advantages to be derived from their particular shape is at present unknown, unless it affords a large surface for the branches of the auditory nerve to be spread upon, and allows a freer communication between those branches than could be produced in any other way.

There is, however, much ground to believe that a more extensive knowledge in Comparative Anatomy, joined with future observations, may clear up this very curious and obscure part of the physiology of the organ of hearing.

I shall finish the present Lecture by an account of the difference between the structure of the membrana tympani of the elephant and that of the hûman ear. It is to Sir Stamford Raffles that I have been recently indebted for an opportunity of making this examination.

He has furnished me with the head of a young elephant preserved in spirit, in which the organ of hearing is in a

perfect state; so that the course of the muscular fibres of the membrana tympani can be traced with a degree of accuracy that was denied me upon the former occasion.

The dimensions of the membrane have been already stated; and I now find that the handle of the malleus lies transversely, terminating in the centre of one of the foci of the oval, and the fibres terminate at the point and all along the two sides, so that those on one side are more than double the length of those on the other.

So great a difference in the form and structure of this membrane from that of the human makes it evident that the animal cannot have a musical ear; and I had only to consider what compensation was made for that loss.

But before I entered upon that subject I endeavoured to ascertain what resemblance to this was met with in other animals.

In neat-cattle, the membrana tympani is more oval in proportion than in the elephant: it is ten-twentieths of an inch long, eight-twentieths of an inch broad; the handle of the malleus lies in the direction of the oval, as seen in the plate, and extends two-thirds of its length; it is not, however, situated in the middle line of the oval, but so much nearer to the anterior side, that the fibres are two-thirds shorter than those on the posterior side.*

In the deer, the membrane is of an oval form, whose transverse diameter is five-twentieths of an inch, the other, five-twentieths; the malleus has its handle nearer the middle line than in neat-cattle; the anterior fibres are

* Plate XCIX.

two-twentieths of an inch long, the posterior three-twentieths of an inch.

In the horse and hare, as well as the cat, the handle of the malleus lies in the middle line of the oval; so that the fibres on the two sides are equal. In the hare the handle is more curved.

From the different structures which I have described, the fibres in the membrana tympani of the horse, hare, and cat, come nearest to those of the human ear, being of one uniform length, although not radii of a circle.

The only compensation the elephant can receive in having such a length of fibre, must be from the slower vibrations enabling it to hear sounds at a greater distance; and such an apparatus corresponds so closely with the beautiful contrivance of the marsupium in the bird's eye, adapting it to see near and distant objects, that it was impossible not to be struck with the similarity.

This is still further confirmed, by the structure of the different parts of the internal organ, more particularly the cells between the tables of the skull.

In the elephant, the small bones, cochlea, and semicircular canals, are larger than in the human ear, nearly in the same proportion with the increased size of the membrana tympani. In that animal there is a very remarkable peculiarity; which is, a cellular structure, occupying the upper and posterior part of the skull, inclosed between the two tables, communicating by a considerable aperture with the cavity of the tympanum, and lined by a similar membrane: the cells communicate freely with one another at their lower extremities, but not near the upper, forming irregular cylinders

placed in a converging direction, towards the cavity of the tympanum.

There is no middle bony septum, separating the cells of the skull belonging to one ear from those which open into the other, but a ready communication between them.

On the anterior part of the skull there is also a similar cellular structure, only much smaller, which communicates with the nose, but is entirely separate and distinct from that which forms an appendage to the organ of hearing.

That the elephant hears farther than other animals, is generally asserted by those who have had opportunities of making observations on the subject.

The organ of hearing in this animal being now found more perfect, and formed upon a larger scale than in any others with which we are acquainted, strongly corroborates this opinion.

Mr. Corse, who resided many years at Tiperah, in Bengal, and paid particular attention to the manners and habits of elephants, concurs in the belief of their hearing being more acute than that of man. The following circumstances are mentioned by him in proof of it.

A tame elephant, who was never reconciled to the sound of a horse moving behind him, although he expressed no uneasiness, if the horse was either before or on one side within his view, could distinguish the sound of a horse's foot at a distance, some time before any person in company heard it; this was known by his pricking up his ears, quickening his pace, and turning his head from side to side.

The cells in the skull of the elephant explain the sounds from the ground striking his ear with more force; and explain

an assertion very generally believed, that an elephant, when he comes to a bridge, tries the strength of it by his foot, and if his ear is not satisfied with the vibration, nothing can induce him to pass over it.

A tame female elephant, who had a young one, was occasionally sent out with other elephants for food, without the young one being allowed to follow. She was not in the habit of pining after her young one, unless she heard its voice; but frequently, on the road home, when no one could distinguish any sound whatever, she pricked up her ears, and made a noise expressive of having heard the call of her young. This having occurred frequently, attracted Mr. Corse's notice, and made him, at those times when the female elephant used such expressions, stop the party and desire the gentlemen to listen: but they were unable to hear any thing till they had approached nearer to the place where the young elephant was kept.

As a matter of curiosity, I got Mr. Broadwood to send one of his tuners with a piano-forte to the menagerie of wild beasts in Exeter-change, that I might know the effect of acute and grave sounds upon the ear of a full-grown elephant. The acute sounds seemed hardly to attract his notice; but as soon as the grave notes were struck, he became all attention, brought forward the large external ear, tried to discover where the sounds came from, remained in the attitude of listening, and after some time made noises by no means of dissatisfaction.

A great lion appeared roused from sleep by the acute sounds, and listened, with his nose resting on the bottom of

his den, in perfect silence, remaining in the same position; but as soon as the grave notes were struck, he started up, endeavoured to break his confinement, lashed his tail, sprung on his hind legs, and by his fury alarmed the spectators, uttering the deepest horrid yells.

LECTURE X.

On Generation.

As there is no subject so interesting to human beings as their own origin, so, to the anatomist and physiologist, there is no inquiry that has ever excited the same degree of ardour of pursuit, as the search after the first rudiments of our existence. To have engaged in this pursuit is so far honourable, as it is the path that the greatest physiologists of all ages have attemped to pursue; and if a desire to excel form a prominent feature in every well-regulated mind, which I trust it does, I may be allowed to exult in no common degree, in being the individual who has succeeded in having brought to light the human ovum, the discovery of which had baffled the efforts of all former inquirers.

This investigation was taken up by the great Harvey, as the only one, after his discovery of the circulation of the blood, that was worthy of his notice, or commensurate with his reputation. He was provided with advantages of no common kind. Under the protection of his king, he had

the controul over his majesty's parks, which provided whatever number of female deer could facilitate his inquiry.

Where Harvey had failed, the subject, from that circumstance alone, became deserving of the consideration of John Hunter; who has left us, in his collection, a series of preparations showing the state of the womb on almost every day after impregnation had taken place in the ewe: but his experiments were attended with no better success than those of his great predecessor.

It has been since proved that the uteri of ruminating animals are not well fitted for such investigations; and the theories that were established in those days respecting the office performed by the corpus luteum were so erroneous, that, till they were exploded, the discovery of the ovum, had it come within the reach of an observer, would probably have been overlooked.

It is rarely the case that any of the secrets of nature are brought to light by regular premeditated attempts at making the discovery: it requires some clue to thread the labyrinth which leads to it; and this clue must be caught by the observing mind from accidental circumstances.

In this way the principle of gravity and the circulation of the blood were discovered, and in this way the human ovum was detected; but neither Newton nor Harvey could have taken advantage of the accidental circumstances without much previous inquiry, and having before hand collected a store of knowledge upon these subjects. It was this stock of acquired facts that enabled them to take advantage of circumstances which less intelligent and less persevering inquirers could not avail themselves of.

The discovery I am about to promulgate was most undoubtedly the result of accident; but similar accidents have before occurred without the discovery having been made: and now that the fact is established, there will not be wanting in every country of Europe opportunities of confirming it. But without the aid of the microscopical observations of a Bauer, the fact, even now, could not have been satisfactorily established; and, with that assistance, I have met with it a second time, while the corpus luteum was completely enclosed in the ovarium, and therefore the ovum could not have been impregnated.

That the professor of Comparative Anatomy to this College should in his Lectures be enabled to prove to demonstration the origin of the human embryo, which the great Harvey, who gave lectures upon the same subject in the neighbouring College of Physicians, was unable to discover, must be gratifying to every one of our members.

In looking back to the times in which Harvey's Lectures were given, and viewing the low consideration in which our corporation was then held, it must now excite a proud feeling to find that the day has at last arrived,—principally, I may be allowed to say, through the exertions of a Hunter, through his invaluable collection, through the lustre he has spread over us, through the researches he opened to our view, converting our art into a science,—in which we can show ourselves not unworthy of being the rivals of that College, in forming a school for the improvement of our profession in the knowledge of the animal economy, and for promoting the pursuits of surgical science.

So small is the human ovum that there is no wonder it

escaped discovery, when the circumstances in which it can be detected but rarely occur.

De Graef and Dr. Kirkringrus were confident that ova were to be met with in all sorts of females; and their observations have a place in the seventh volume of the Philosophical Transactions, pages 4018. and 4052. Haighton and Cruikshanks made similar declarations; but by mistaking the formation of the corpus luteum for the effect of impregnation, which at that time was an error generally adopted, they got entangled in theoretical opinions, that misled them in their future inquiries, and rendered such parts of their statements as were true quite unsatisfactory.

Accident has done what no predetermined experiments had effected upon this most interesting subject; it has enabled us to destroy the false theories in which the formation of the ovum was enveloped, and to detect it both in the ovarium and in the human uterus, before it had become attached to it.

I shall describe the circumstances that led to this discovery in the order in which they occurred.

A servant-maid, twenty-one years of age, had been courted by an officer, who had thrown out the lure of marriage as a temptation in aid of the importunity of his addresses. She was little in the habit of going from home; and not having done so for several days, one morning she requested a fellow-servant to remain in the house, as she wished to call upon a friend, and should be detained some time. This was on the seventh of January, 1817. After an absence of several hours she returned, and brought with her a pair of new corsets, and some other parts of female

dress which she had purchased. In the evening, she got one of the maid-servants to assist her in trying on the corsets. In the act of lacing them, she complained of being sick and all over unwell, but recovered on taking a little brandy, and soon after went to bed.

Next day she was much indisposed: this was attributed to her monthly periods having been accidentally checked, as they had not come on, although the time had arrived. On the following day there was a wildness in her manner, and she appeared much distressed in her mind; a considerable degree of fever came on, which required her being confined to her bed. On the thirteenth, she had an epileptic fit, followed by delirium, which continued till the fifteenth, on which day she died about ten o'clock in the forenoon.

After death the uterus was found to be enlarged beyond its usual size in a virgin state, and considerably more vascular.

Upon making enquiries of her fellow-servants, many circumstances were mentioned that made it highly probable that on the morning of the seventh, when she was just on the point of menstruation, her lover had succeeded in gratifying his wishes; her passions being then, from the state of the womb, more readily excited than at other times; and had got her with child, so that when she died she was in the seventh or eighth day of her pregnancy.

The uterus was carefully preserved in spirit of moderate strength till I had leisure to examine it, in a light favorable for that purpose.

In this examination I was assisted by Mr. Clift. On observing accurately the right ovarium, there was upon the

most prominent part of its external surface a small ragged orifice: this induced me to make a longitudinal incision in a line close to this orifice, and a canal was found leading to a cavity filled with coagulated blood, surrounded by a narrow yellow margin, in the structure of which the lines had a zig-zag appearance.

The cavity of the uterus was then opened, by making an incision through the coats from each angle; and where these met in the middle, a third incision was continued down through the os tincæ to the vagina. The three angles were turned back so as to expose the cavity, and the sides were gently separated from each other. The os tincæ was completely blocked up by a plug of mucus, so that nothing had escaped by the vagina; the orifices leading to the Fallopian tubes were both open, and the inner surface of the cavity of the uterus was composed of a beautiful efflorescence of coagulable lymph resembling the most delicate moss. This efflorescence had fibres of greater length on the posterior surface, a little way beyond the os tincæ, than at any other part. Being certain that nothing could have escaped, I began gently shaking the efflorescent fibres with a needle-point, and said to Mr. Clift that if we found any thing it would be in that part. During this examination, the whole of the uterus was immersed in spirit, and the needle-point in its movements brought a small transparent body above the surface of the efflorescence of coagulable lymph, but it immediately sunk again: I raised it a second time, and saw distinctly that the moment it was again exposed to the spirit it became opaque; it had an oval shape. I cried out, "We have got it." Mr. Clift, less sanguine, and not seeing the change of colour,

my eye being directly over the basin, believed that it was only a little coagulated lymph. Perfectly satisfied that I had got the ovum, I went immediately to Mr. Bauer, that he might submit it to the test of the microscope, and by this means have the fact completely confirmed.

So delicate were the membranes, and so completely was it obscured in its mossy bed, that had the parts been examined in a recent state it must have been infallibly destroyed; and had it not immediately afterwards come under Mr. Bauer's microscopical observation, it never could have been satisfactorily identified, or represented upon paper.* The annexed drawings of the ovum prove to what an excellence microscopical observations can be carried, since in so small a particle of animal matter, not only the ovum itself, but one of the effects of impregnation is ascertained; the seat of the brain and spinal marrow being marked out before the ovum is attached to the uterus. These two projections were so permanent, that after this vesicular ovum was dried, they were distinctly seen by means of a common lens, and in a bright light by the naked eye. The microscopical observations on the unimpregnated ovum have also proved that the amnion and chorion are both membranes belonging to the ovum, since they are formed before impregnation.†

As the ovum was thus happily met with before it had formed any attachment to the efflorescent coat of coagulable lymph, which lined the cavity of the uterus preparatory for its reception, we now know that the chorion does not become vascular till the ovum comes to its destination, and forms an attachment to some part of the mother, with which it

* Plate CI. † Plate CIV.

opens a communication by means of vessels; the part is immaterial, whether, as in this instance, it was the cavity of the uterus, or any part of the Fallopian tube, as in those cases in which the ovum is arrested in that canal, or the ovarium when accidentally retained there. Cases of these different kinds have come under my observation.*

It is probable that if this woman had lived a few days longer, the embryo would have arrived at the state represented in Dr. Hunter's great work, inclosed in the fibrous structure surrounding it, secluded from the cavity of the uterus, and in that case the valuable information we have now acquired would have been lost. Dr. Hunter considered the ovum he has represented three weeks old.

Mr. Bauer's description of the ovum I shall give in his own words, than which none can be more clear and satisfactory:—

"On closely examining the subject under the microscope, "I found it consisted of membrane, which, considering the "extreme minuteness of the object, is of considerable thick-"ness and consistence, very little transparent, quite smooth, "and milk-white, forming a kind of bag of an irregular oval "shape, not quite $\frac{19}{100}$ parts of an inch in length, and in its "middle about $\frac{9}{100}$ parts of an inch broad: on one side it "has an elevated ridge or loose fold along the whole length; "and on the opposite side it is open nearly to the same "extent, but has no appearance of being torn, the edges of "the membrane being smoothly rolled inwards, which gives "it much the shape of a little shell of the genus voluta.

* Plates CVI. CVII.

" When laid on glass, the membrane admitted of easily " being laid open on both sides by the point of a fine camel- " hair pencil. When thus opened, I found it contained " another smaller bag somewhat less than $\frac{18}{100}$ parts of an " inch long, and not quite $\frac{5}{100}$ parts of an inch broad, ending " at the upper extremity nearly in a point; but the lower " extremity was very obtuse, and in the middle it was " slightly contracted.

" This inner bag consisted of a very thin perfectly smooth " and glossy membrane, which seemed to have considerable " strength, as it bore to be rubbed pretty strongly, not only " with the camel-hair pencil, but also with the point of the " quill: it seemed to be filled with some thick slimy mucus, " as an impression made upon it with the point of the quill " remained for a considerable time visible: it contained two " round corpuscles apparently more opaque, and of a " yellowish tint: they were not only visible through the " transparent membrane, but they elevated the membrane " over them so that the light and shade made them to be " distinctly seen; and by slightly pressing the bag with the " quill between the two corpuscles they could be separated " to a greater distance from each other, but on applying " moisture they returned quickly to their former position, as " if there was a connection between them. This little bag " was, along its whole length, strongly fixed with its back " part to the outer membrane; at least I could not remove it " with the camel-hair pencil, and more force I was afraid to " employ. I attempted to open the little bag, if possible, to " extract the corpuscles, but on piercing with the point of a " very small needle the upper extremity, a thick slimy

" matter like honey came out, and with the membrane
" adhered to the needle, so that I durst not proceed farther;
" and fearful of spoiling the whole I gave up the attempt,
" and left the subject on the glass to dry; but I observed, as
" the spirit and moisture gradually evaporated, so the little
" bag flattened, and, as if melting, shrunk into the outer
" membrane and almost disappeared, but in a strong light
" was still visible.

" When quite dry, its colour changed to a light yellowish
" brown, and it lay quite loose on the glass, except at the
" upper extremity where I attempted to open it: this part
" adhered firmly to the glass, requiring being moistened to
" admit of its removal."*

Upon examining the cavity in the ovarium in which the ovum had been formed, it was found to be of an oval figure: it contained a coagulum of blood, and was surrounded by a yellow margin, similar to that which surrounds the corpus luteum.

These corpora lutea are thus proved to be the glandular structure which forms the ovum, and when the ovum is expelled, gradually disappear.

Till now these bodies have always been considered as the effect, not the cause of impregnation, so that without impregnation there would neither be ova nor corpora lutea, and the presence of that body was allowed to be an undeniable mark of conception having taken place. This error must have arisen from the circumstance of there being almost always, in the ovarium of a woman who dies in child-bed, a corpus luteum preparing another ovum, to be ready for

* Plate CIV.

future impregnation, which was usually mistaken for that belonging to the child born; whereas the former corpus luteum, in the course of nine months, had nearly if not entirely disappeared.

In this ovarium there were two corpora lutea, one from which the ovum had been so recently expelled that the external orifice was not yet completely closed, and another coming forward, but not yet arrived at its full size, and therefore there was no appearance of an ovum or even of a cavity*; the whole in its consistence resembling a solid glandular structure loaded with blood-vessels.

This new fact led me to examine the *ovaria* in the preparations in this Collection, both in women full grown and just arrived at puberty, in which the hymen was entire; in many such ovaria the corpus was distinctly seen.†

In this investigation I have not only been able to show the appearance of the human ovum, to trace it through its whole course from the ovarium to the uterus, but to determine a point so much disputed; that is, whether the semen is certainly carried to the ovarium.

Its being carried to the uterus was proved by Mr. Hunter by a direct experiment‡, which is corroborated by the structure of the male and female organs in many animals; in none more strongly than those of the sea-otter and dugong§: but that it is absolutely carried to the corpus luteum itself, in which the ovum lies, before it leaves the ovarium, is now

* Plate CII. † Plates CVIII. CIX. CX.

‡ J. Hunterus canis fœminæ inter coeundum occisæ, uterum aperuit; quo facto maris semen in ipsum uterum, per saltus intromissum clare vidit.

§ Plates CXV. CXVI.

proved beyond all possibility of doubt by the following case:—

A lady, aged thirty-nine years, died on the ninth of June, 1819, after having experienced various and severe sufferings, which, with the exception of a short period of convalescence, had lasted from the twelfth of December, 1818, to the moment of her dissolution.

Upon examining the body after death, it was found that an ovum in the left ovarium had been impregnated, and not afterwards allowed to escape from the corpus luteum in which it was produced, the chorion having most probably formed an adhesion to the side of the cavity in which the ovum lay, (an instance of which will be mentioned to have occurred in the quadruped:) as the embryo increased in size, the ovarium enlarged along with it; but not being able to keep pace with the growth of the child, gave way in three different places; and when the embryo had arrived at the fourth month, a portion of the edge of the placenta was ruptured, and the mother was destroyed by the hæmorrhage.

The fœtus was completely enclosed in the ovarium, and the different parts at which it had been ruptured are distinctly seen in a much clearer manner than could have been done in any preparation of the parts themselves.*

It is impossible to take up the subject of generation, and be silent upon the subject of menstruation,—a flux of blood from the womb, which appears to be essential to health in all women not with child, and which immediately ceases on their being pregnant.

This periodical flow of blood from the womb, it is to be observed, is peculiar to the human species, and the monkey-

* Plates CVI. CVII.

tribe, and therefore in no respect essential to the propagation of the species of animals at large.

It arises from the uterus in women and monkeys being of a compact form; so that when once a great derivation of blood is made to that part, and not wanted, it could not otherwise be readily carried off.

In quadrupeds, whose uteri have a different construction, when they are in heat, and the ova ready for impregnation, the uterus has its blood-vessels very turgid; and if the female does not receive the male, this increased circulation gradually subsides, the distribution of the blood-vessels being favourable for its doing so.

In the human species, the fulness of vessels of the womb preceding menstruation corresponds with the state of heat in the female quadruped, and shows that the ova at that period are most commonly fit for impregnation: when no impregnation takes place, and the ova are blighted, they pass out of the ovaria and uterus, and the next menstruation unloads the vessels, and restores the womb to its ordinary state.

The females in India, where, from the warmth of the climate, all the internal economy respecting the propagation of the species goes on more kindly than in changeable climates, reckon ten months as the period of utero gestation. In the Apocrypha, the Wisdom of Solomon, chap. vii. v. 2. "And in my mother's womb was fashioned to be flesh in the "time of ten months."

This circumstance seems to prove that immediately before menstruation, when all the appendages of the womb are loaded with blood, the ova and the ovaria are more fre-

quently ready for impregnation, in the climates most congenial for propagation; and therefore the mode of reckoning is from the previous menstruation, which is ten months before the birth.

The menstrual discharge has been considered as a previous step to impregnation; and if a married woman is not with child soon after the monthly period has taken place, she is consoled by the chance of being more fortunate after her next period. I shall mention the following case as a complete refutation of this theory:—A young woman was married before she was seventeen; and although she had never menstruated, became pregnant. Four months after her delivery she became pregnant a second time; and, four months after her second delivery, she was a third time pregnant, but miscarried: after this she menstruated for the first time, and continued to do so through several periods, and again became pregnant. That the two ovaria are under the same circumstances respecting the formation of corpora lutea no reasonable person ever doubted, being led by general observation to such a conclusion; it is curious, however, that we have been without proof upon this subject, till Mr. Hunter published an experiment in the Philosophical Transactions, to determine whether the number of young was equally divided between the two ovaria.

He took two sows from the same litter, deprived one of an ovarium, and counted the number of pigs each produced during their natural lives. The sow with two ovaria had one hundred and sixty-two; the spayed sow only seventy-six. So that each ovarium is proved to have nearly the same proportion. But, what is strange in a man of his

accuracy, there was no mention of the proportion of males.

This inaccuracy in Mr. Hunter's experiment has left an opening, which a French author has taken advantage of; and, some years ago, published a work which was widely circulated in Paris, and universally read, positively declaring that the males were produced by the one ovarium and the females by the other, assuming to himself the power of so managing the position of the woman in the time of connection, that certainly she should have a boy or a girl; and he actually made public the names of the mothers who had followed his advice, and by so doing succeeded in their wishes. It is certainly a disgrace to science that there was no proof to oppose to this assertion; but this question has been since for ever set to rest by the following case, which Dr. Granville, at my desire, communicated to the Royal Society.

A woman, forty years of age, died at la Maternité, in Paris, six or seven days after delivery, of what had long been suspected to be a disease of the heart. The body was opened, in the presence of Dr. Granville, and the disease was found to be an aneurism of the aorta. On examining the womb, it was four times at least the size of what it is in the unimpregnated state: it had acquired its full developement on the right side only, where it presented the usual pear-like convexity; while the left formed a direct straight line, scarcely half an inch* distant from the centre, although more than two inches could be measured from the same point to the outline of the right side. The Fallopian tube and the ovarium, with the other parts on the right side, had the

* Plate CV.

natural appearance; but were not to be found in the left. The rudiments, for they deserved no other name, were discovered lying in the interior part of the cavity of the pelvis, loosely connected with the cervix of the uterus; the ligamentum rotundum inserted into the superior and interior ridge of the os pubis of the same side. In dissecting this mass, the vestiges of an ovarium were brought to view, dry, horny, and shrivelled.

This woman had been the mother of eleven children of both sexes; and a few days before had been delivered of twins, one male and one female. This forms a complete answer to Mr. Millot, the French writer, on the art of procreating the two sexes at pleasure.

Superfœtation in the human species is a subject upon which nothing decisive has been determined: it was long wholly discredited, although individual cases have occasionally been brought forward that, if the authority could be relied on, were irresistible; but till we knew exactly in what conception consisted, all reasoning upon the subject remained hypothetical.

In general, in cases of twins, it appears that both the ova are impregnated in the same ovarium; consequently they are received and deposited nearly together in the uterus: so that the edges of the two placentæ are blended together, which we find to be the case. This so commonly occurs, that when there happens to be twins, the secondines of which are unconnected, consequently the children are born entirely separate, at the distance of some hours, and at the time the first placenta is expelled, there is no notice of there being a second child to be brought forth. Such cases have been mistaken for superfœtation. For this, however, there is not the

smallest ground, since the circumstance by which ova may be kept separate can be readily accounted for: it is only necessary to suppose one ovum in each ovarium had been impregnated at the same time, and deposited in the uterus so widely apart from each other that the placentæ never in any way became connected together.

In cases of superfœtation, it is probable that it can only happen where there is an ovum ready for impregnation in each of the ovaria, and only one has been impregnated by the first connection, and a second connection taking place soon after, has impregnated the other.

We now know that the passage from the uterus to the ovaria continues open long after that from the vagina to the uterus is closed: therefore, after an ovum in one ovarium has been impregnated, a second connection may impregnate an ovum in the other ovarium; and this may happen at any distance of time within the period after impregnation at which the os tincæ is rendered impervious, which may be twenty-four hours.

These facts being established, and it being admitted by most naturalists who have bred dogs that superfœtation is very common in animals, the bitch, after being lined, readily admitting a dog of a very different kind to have connection; and where this has happened, two different descriptions of puppies are found in the litter, some of them resembling each of the fathers, and what is curious, not remarkably resembling the mother.

Although such assertions are general, it is only lately that I have been able to have the fact established upon good authority, as coming within the circle of my own particular

friends, one of whom has the proofs now alive in his possession.

In 1819, a setter bitch was lined in the morning by a pointer. The bitch went out with the game-keeper, who had with him a Russian setter of his own, who also lined her in the course of the forenoon. She had a litter of six pups: two only were kept, and are still alive in Staffordshire. One of these bears an exact resemblance to the pointer, the other to the Russian setter; so that in both cases the male influence was predominant, as none of the others bore a striking resemblance to the mother.

The only way in which this fact of superfœtation can be absolutely established in our own species is in cases of twins, where the children differ so much in colour as to show that both cannot belong to one father.

Several cases of women in the West Indies having at one birth a black and a white child, have a place in the Philosophical Transactions, and some others are handed down by oral tradition in the different islands which I have visited. Not satisfied with these accounts, in a country in which there is a great fondness for the marvellous of every kind, I have never desisted from pursuing the inquiry, and have at last succeeded in establishing the fact in the most satisfactory manner.—A particular friend of mine, who has an estate in the parish of St. Thomas in the East, near the Manatee river, knows a black woman who has two children now alive, that are twins and were suckled together; one quite black, the other a mulatto. The woman herself does not hesitate in stating the circumstances. One morning, just after her husband had left her, a soldier for whom she had a partiality came into the

hut, and was connected with her about three or four hours after her leaving the embraces of her husband.

Having gone through in a regular manner all the facts and observations which I have made with respect to generation in the human species, I shall now examine the structure of the ovarium, and the changes it goes through in forming the corpus luteum; first in the human species, and afterwards in quadrupeds.

The natural structure of the ovarium is more readily ascertained before the age of puberty than afterwards, since no attempts are made before that period to form corpora lutea. Its structure is nearly the same in women and in quadrupeds. It is of a loose open texture, in which, more particularly near the circumference, a number of globular cells are met with.

The corpus luteum, from its appearance, seems to be entirely a new formation, distinct from that of the ovarium itself; it is always met with in the substance, not in the cells. In its increase it compresses the parts surrounding it so much, that when of its full size, and even where there are several in the same ovarium, that body is not much increased beyond its natural dimensions.

The structure of the corpus luteum is of a very particular kind, and is not distinctly seen in small animals, or those that have numerous litters; but in the cow, which commonly has only one calf at a birth, the corpus luteum is so large, that when it is magnified the structure can be made out. It is a mass of thin convolutions bearing a greater resemblance to those of the brain than of any other organ. Its form is an irregular oval, with a central cavity; and in some animals its

substance is of a bright orange colour when first exposed.* Corpora lutea are found to make their appearance immediately after puberty, and continue to succeed each other as the ova are expelled, till the period arrives when breeding no longer goes on.

As the object of these observations is to prove that corpora lutea are the glands formed purposely for the production of ova,—that they exist previous to and are unconnected with sexual intercourse, and when they have fulfilled their office of forming ova are afterwards removed by absorption, equally whether the ova are impregnated or not,—I shall not take up your time further than by detailing a number of facts which will be illustrated by drawings.

That corpora lutea are formed in a state of virginity is proved both in the human species and the hog tribe, as will be ascertained by the following examinations.†

In a young woman, twenty years of age, with a perfect hymen, one of the ovaria was found to contain a corpus luteum, in which was an ovum arrived at its full size; the second covering or chorion already formed, by means of which the ovum had a slight adhesion to the inner surface of the cavity of the corpus luteum: so that if this woman had lived, and this ovum had been impregnated, it would have proved an ovarium case similar to that already detailed.‡

This ovum, when examined in the microscope, differed in nothing from that already described, but in being of a

* Plate CXII. † Plates CVIII. CIX. CXIII. CXIV.
‡ Plate CX.

smaller size in the proportion of $\frac{15}{200}$ to $\frac{10}{200}$, in the whole being transparent, and in the chorion not having extended itself completely over the anterior surface of the ovum. The Fallopian tube of that side was fuller than the other.

The fimbriæ were spread out and unusually vascular; so that every preparation was made in the Fallopian tube corresponding to the formation of the ovum.

To have met with the human ovum before impregnation has taken place, and to find in that state the gelatinous molecule it contains is uniform in its appearance and consistence, and that the ovum met with after impregnation had undergone a change, even before taking up a fixed residence in the uterus, shows beyond a doubt that this change is effected by the addition, whatever it may be, received from the male semen, and the increase it acquires in size must arise from the same cause. This change is an advance towards coagulation, beginning at two central points, so as to divide the mass into nearly two equal corpuscles, preparatory to their becoming more solid.

I have met with corpora lutea in virgins so early as fourteen years of age; and there are two girls in St. Ann's, Soho, that have had children, one at thirteen, the other at twelve.

The cow is considered to arrive at puberty at two years old; and the corpus luteum, whose structure has been detailed, formed the ovum of the first calf. I have, however, met with an instance of a calf within the first year having bred: this must undoubtedly be considered as a rare occurrence.

In the hog tribe the age of puberty is six months; and at four months the ovarium is not found to have any appearance of incipient corpora lutea: when the animal is between

five and six months old, several had made considerable advance *, and in the ovarium of a sow nearly six months old, corpora lutea were completely formed; the ova having probably been destroyed by the violence employed in killing the animal, the central cavities were filled with blood.

In another virgin-sow nearly six months old, we were so fortunate as to detect corpora lutea in the act of bursting for the expulsion of the ova. It is decided by this proof that females part with ova whether there is sexual intercourse or not, and with such force that the cavity of the corpus luteum is absolutely inverted, so that the ovum is completely exposed to the semen of the male. The extravasation of blood in rupturing the ovarium and inverting the corpus luteum is in many instances so great that some of it passes through the vagina, which when met with after the female has had the male, is considered as a proof that impregnation has taken place. As soon as the ovum is expelled, the corpus luteum recovers itself and regains its former state.

In proof of corpora lutea forming in succession, and probably nearly in the same number whether the female receives the male or not, was seen in a woman who died a virgin forty-seven years of age: on opening the ovaria, the vestiges of seven corpora lutea remained in one, and in the other there were five.

It is a curious fact respecting pigeons, which I have learnt from Sir John Sebright, that when mated they lay their eggs earlier than when kept from the male; they do not lay a greater number, but lay at all seasons, while the others only lay in the spring.

* Plates CXIII. CXIV.

I have mentioned that the fœtus of the human species as well as of quadrupeds in general is attached by a placenta to the uterus and receives nourishment from that source, the blood of the embryo being aerated by that of the mother.

This is a subject that has been little considered, and the different forms of the placenta have not been at all attended to; but as I mean at the close of these Lectures to take up this subject in a new point of view, I shall not at present go further than to mention that the human placenta is in its form and appearance different from that of all other animals.

Many circumstances respecting the influence of the mind of the mother upon the fœtus, as well as what belongs to the influence of the semen of the male, are still unknown and probably may never be revealed; but the following occurrence which has lately taken place, and is in itself of a most curious and interesting nature, throws much light upon the enquiry, and with the account of it I shall conclude this Lecture.

An English mare was covered by a quaga, a species of wild ass from Africa, marked in a manner somewhat similar to the zebra. This happened in the year 1815, in the park of Earl Morton, in Scotland. The mare was only covered once, went eleven months four days nineteen hours; the produce was a hybrid marked like the father. The hybrid remained at the dam's foot above four months, was then weaned, and removed from her sight: she probably saw it again in the early part of 1816, but never afterwards, as the mare came to England to Sir Gore Ouseley, Bart., and in

February, 1817, was covered by an Arabian horse, and had her first foal a filly. In May, 1818, was covered again by the same horse, and had a second. In June, 1819, was covered again, but this year she missed; but in May, 1821, was covered a fourth time, and had a third: all of these are marked like the quaga.

The hybrid's colour is light dun approaching chesnut; call it an undecided colour, and by no means handsome. The marks on it are fewer in number than on the dam's produce by the Arabian horse.

This curious circumstance of a mare having foals by a horse, marked like the young she had four years before by an ass, and from whom she had been at a distance all that time, is one of the strongest proofs of the effect of the mind of the mother upon her young that has ever been recorded.

The facts may be said to be preserved in this College, since a series of paintings, including the quaga, the mare, the Arabian horse, the hybrid, and the three foals is deposited there.

Haller observes that the female organs of the mare appear to be corrupted by the unequal copulation. Since the young foal of a horse from a mare, which previously had a mule by an ass, has something asinine in the form of its mouth and hips.*

Beecher, in his Physiology, says, when a mare has had a mule by an ass, and afterwards a foal by a horse, there are evidently marks in the foal of the mother having retained

* Videtur etiam partes genitales matris ab ea inæquali veneri corrumpi. Esse in pullo equæ, quæ priori partu asinum suscepit aliquid asinini in ore et coxis. — *Hal. Elem. Physiol.* viii. p. 104.

some ideas of her former paramour the ass, from which such horses are commended on account of their tolerance and other similar qualities.*

* Equa ex primo conceptu *per asinum* facto mulum quidem parit; conceptu autem et quidem adhibito *equo* iterati, equus nascitur et talis in quo manifesté insignes reperiuntur de priori *idea asinina* reliquiæ; unde tales equi a tolerantia aliisque similibus qualitatibus laudari solent. — *Beecher*, *Phys. subter.* p. 214. *Ed.* 8. *Lips.* 1703.

LECTURE XI.

On Animals imperfectly or preternaturally formed at the Time of their Birth.

INSTANCES of animals being brought forth whose organs of generation are preternaturally formed sometimes occur, and have been commonly called Hermaphrodites: this term however should be confined to those only in which there is a mixture of the male and female organs in the same animal.

Examples of this kind have been rarely noticed: they have been met with at very distant periods of time, and confined to too few species of animals to afford extensive opportunities for collecting observations respecting them.

To this cause must be attributed the little information that has been acquired upon so curious and interesting a subject.

Monstrous productions, having a mixture of the male and female organs, and which deserve the name of hermaphrodites, appear to arise most frequently in neat-cattle; and the

circumstances under which this occurs are now generally known, and the animals have been called Free-martins.

This compound animal attracted the attention of the late Mr. John Hunter; and a paper of his containing a description of the organs of generation of different free-martins, to show that they are by no means uniformly the same, or partake equally of the parts belonging to both sexes, is published in the Philosophical Transactions, Vol. LXIX.

To these dissections I shall add an account of similar malformation of the organs of generation in a dog. The subject having already been considered an object deserving the attention of so great a physiologist is an inducement for bringing forward any new facts, and observations which have been made upon it.

The causes of monstrous productions of every kind are at present equally unknown, but it is highly probable that they are very similar; and when once they have been brought into action, it would be reasonable to suppose that the influence should be continued to several young in succession; this is, however, by no means the case, for of all the monstrous productions that have come under my observation, none of them have been either immediately preceded or followed by a monster of the same or of any other kind.

In the neat-cattle, the free-martin is most commonly met with where there are twins; one is a free-martin, and the other is always a perfectly formed male. In the human species there have been instances of mothers having alternately a perfect and a monstrous child; so that these observations lead to the idea, that monstrous productions do

not follow immediately upon one another; that they sometimes alternate, but are commonly only one in a family, of which the others are perfectly formed.

From Mr. Hunter's observations we learn, that in all the instances of free-martins which he examined, no one had the complete organs of the male and female, but partly the one, and partly the other, forming a mixture of both; and what is deserving of notice the ovaria and testicles, in all of them, were too imperfect to perform their functions.

There is much reason to believe, that no instance of an hermaphrodite, in the strict sense of the word, has ever occurred in the more perfect quadrupeds, or in the human species; for, when we consider the bones of the pelvis, to which the organs of generation are connected, it is difficult to conceive in what way the complete parts of the male and female could be placed distinct from each other, and no instance of its having happened is to be found in any record which can be depended upon.

As much has been said by authors respecting hermaphrodites, particularly in our own species, and histories of them have a place even in the Philosophical Transactions, it may not be improper to explain the different kinds of monstrous productions which have been frequently mistaken for a complete mixture of male and female organs.

This enquiry into the subject of hermaphrodites I shall pursue in the following order: First, Examine into such malformations of the male organs as led to the belief of the persons being hermaphrodites. Second, into such malformations in the female organs as have led to the same conclusion.

Thirdly, Those who, from a deficiency in their organs, have not the character and general properties of the male, and may be called neuters.

Fourthly, Those in which there is a real mixture of the organs of both sexes, although not sufficiently complete to constitute double organs; which, I believe, to be the nearest approach towards an hermaphrodite that has been met with in the higher orders of animals. It is much in favour of this opinion, that every account I have met with in authors may be referred to one or the other of these heads.

Baron Haller, who has treated this subject with his usual perspicuity, has collected in one point of view the histories of reputed hermaphrodites, from almost every author that preceded him; and his conclusions agree with what is now advanced.

In considering the malformations of the male organs of generation, which put on the appearance of both the male and the female organs, I cannot better illustrate the description than by taking up the cases mentioned in Cheselden: one is a negro, the other an European.

From an examination of the engravings of that work, no superficial observer would harbour a doubt of their being complete hermaphrodites; and the opinion of Dr. Douglas, which is annexed, in favour of the existence of the female organs, strengthens Cheselden's authority.

In these cases, however, there is much reason to believe, that the parts were only those belonging to the male, very much distorted by an imperfection of the scrotum, which was divided into two separate bags, with a deep slit

between them, resembling very much the labia pudendi, and the opening into the vagina; over these hung down the penis: the imperfection of the septum of the scrotum extended to the canal of the urethra.

This is not unlike the fissure in the hair-lip being continued through the bony palate, a circumstance often met with.

The under surface of the penis was attached, through its whole length, to the two bags containing the testicles, looking like a preternatural clitoris, to which it bore a more perfect resemblance from the absence of the urethra.

The urine passed through a preternatural termination of the urethra in the perinæum, and came out externally in the space between the testicles, which formed an enlarged aperture that had been mistaken for a narrow vagina, in consequence of its allowing an instrument to pass to some distance, by conducting it to the bladder.

A similar case occurred at Swaffham, in Norfolk; it was a boy ten years old, whose three brothers were perfectly formed: the penis was of the natural size, but the urethra terminated in perinæo, and the scrotum was split, the intervening space naturally resembling an imperforate vulva.

Haller dissected a ram, in which the parts had been supposed to be those of an hermaphrodite. He found the animal to be a male with the imperfections above mentioned; and on comparing the dissection with many instances which have been stated by different writers, both in the human species and in quadrupeds, he considered them all to have been similar in the conformation of the parts of generation.

Such malformation of the parts in the male is particularly deserving of attention, as it is that which, more than any other, has been mistaken for a mixture of both sexes.

It often occurs in different degrees of imperfection; and in some instances, can be materially diminished by the assistance of the surgeon, although the greater number of cases are beyond the reach of art.

It may be supposed, that so great an imperfection in the structure of the penis, is necessarily attended with others in the more essential organs of generation; I shall therefore give an instance to the contrary.

In a case of this kind, in which the canal was continued to within two inches of the external orifice at the glans penis, the deficiency of the urethra just before the scrotum was so great, that every attempt to close the aperture necessarily left proved ineffectual; and under these circumstances the person married. When he had connection the emission was complete, which proved that the testicles were perfect; but the semen always passed out at this orifice.

Mr. Hunter was consulted to remedy, if possible, this inconvenience, and enable the person to beget children. After the failure of several modes of treatment which were adopted, Mr. Hunter suggested the following experiment:—He advised that the husband should be prepared with a syringe fitted for the purpose, previously warmed; and that, immediately after the emission had taken place, the semen should, by means of the syringe, be injected into the vagina, while the female organs were still under the influence of the coitus, and in the proper state for receiving the semen.

This experiment was actually made, and the wife proved

with child. Upon a subject of this kind it is proper to speak with caution, but from all the attending circumstances, no doubt was entertained by Mr. Hunter, or the husband, that the impregnation was entirely the effect of the experiment.

In 1806, twenty-five years afterwards, I had an opportunity of examining the parts of the husband, and found the testicles perfect, and no other deficiency but that in the urethra, and have no doubt of the man being capable of having children in the way proposed by Mr. Hunter.

Spallanzani's experiments on animals were made several years after this, which, conducted under the directions of Mr. Hunter, had been attended with success.

In the female, there are two malformations of the organs of generation, which give an appearance to the external parts tending to mislead the judgment respecting the sex.

One is an enlargement of the clitoris, which is stated by authors to grow to an immoderate size in warm climates, and to resemble a penis.

In cold countries, instances of this kind do not occur; and even within the tropics, they are now rarely met with to such an extent.

The accounts that have been given we must suppose are much exaggerated; for it is scarcely to be believed, that any enlargement which the clitoris is liable to can give it a sufficient resemblance to a penis, to be productive of any mistake.

The most remarkable instance of this kind that has come to my knowledge, was a Negro woman who was purchased by General Melville, in the island of Dominica, in the West

Indies, about the year 1774. She was of the Mandingo nation, twenty-four years of age; her breasts were very flat, she had a rough voice, and masculine countenance. The clitoris was two inches long, and in thickness resembled a common sized thumb: when viewed at some distance, the end appeared round and of a red colour, but upon closer examination was found to be more pointed than that of a penis, not flat below, and having neither prepuce nor perforation: when handled it became half erected, and was in that state fully three inches long, and much larger than before: when she voided her urine, she was obliged to lift it up, as it completely covered the orifice of the urethra. The other parts of the female organs were found to be in a natural state.

Dr. Clark, who has favoured me with this account from his own examination, mentions, that among the women of the Mandingo and Ibbo nations a large clitoris is very common; and in several instances which came under his observation, in the course of his practice of midwifery, in the island of Dominica, the clitoris was an inch long, and thick in proportion, but attended with no other preternatural appearance.

The case above mentioned, while it proves that the clitoris is sometimes of a very extraordinary size, also shows, that when so enlarged it is unconnected with any mixture of the male organs.

The other malformation is a protrusion of the internal parts, which may be considered a prolapsus uteri, and therefore more a disease than an original malformation; it is probable, however, that if the parts had been perfectly

formed, and had acquired their due size, this change of their situation could not happen.

The womb, thus displaced, has put on an appearance resembling a penis, and has been actually mistaken for one, even by medical men of character, who examined the parts.

The following case of this kind came under my own observation:—

A French woman had a prolapsus uteri at an early age, which increased as she grew up; the cervix uteri was uncommonly narrow, and at the time I saw her (when she was about twenty-five years old) projected several inches beyond the external opening of the vagina; the surface of the internal parts, from constant exposure, had lost its natural appearance, and resembled the external skin of the penis; the orifice of the os tincæ was mistaken for the orifice of the urethra. This woman was shown as a curiosity in London; and in the course of a few weeks, made four hundred pounds. I was induced by curiosity to visit her, and on the first inspection discovered the deception; which, although very complete to a common observer, must have been readily detected by any person intimately acquainted with anatomy. To render herself still more an object of curiosity, she pretended to have the powers of the male. As soon as the deception was found out, she was obliged to leave England.

The history of an hermaphrodite is published in the sixteenth volume of the Philosophical Transactions, which proves to be exactly similar to this, as is sufficiently ascertained by the menses flowing regularly through the orifice of the supposed penis.

The French physicians were, however, so convinced of her manhood, that they made her change her dress, and learn a trade.

To this she readily submitted; and the account says, she could perform very well the functions of a man, but not those of the other sex. This woman was also French.

A third French woman came to London as an hermaphrodite, and what is extraordinary, the French surgeons were misled respecting the nature of the case, in consequence of being unable to pass an instrument into the bladder.

When I saw her, I found, upon examination, that the orifice of the vulva was impervious except an opening at the upper part, which led both to the meatus urinarius and uterus, and by bending a probe into the curve of a catheter, readily passed it into the bladder, which removed all doubts respecting the nature of the case.

It is probable that the most common imperfection in the male organs of generation is a defect in the structure of the testicles; that organ remaining in its fœtal state, and never becoming fitted to perform its functions. When this happens, the person cannot be considered of the masculine gender, but of the neuter; having, properly speaking, no sex.

Such persons in their general external form have neither the true character of a man nor of a woman.

These neuters are more common than is generally believed: they vary in their external appearance, some being an exact medium between the male and the female, and others having a greater resemblance to the one or the other sex; which bias may be the result of turn of mind, occupation, or other circumstances. Probably, only those

whose form is very like females attract the notice of common observers, so as to have their defects discovered.

The following instances of children with imperfect organs having remained neuters, in consequence of the testes not undergoing at puberty the change necessary for producing that influence on the constitution which stamps it with the character of the sex, have come under my own observation.

A marine soldier, aged twenty-three, in the year 1779, was admitted a patient into the Royal Naval Hospital at Plymouth, under my care. He had been there only a few days, when a suspicion arose of his being a woman, which induced me to examine into the circumstances. He proved to have no beard; his breasts were fully as large as those of a woman at that age; he was inclined to be corpulent; his skin uncommonly soft for a man; his hands fat, and short; his thighs and legs very much like those of a woman; the quantity of fat upon the os pubis resembled the mons veneris; the penis was unusually small, as well as short, and not liable to erections; the testicles not larger in size than we commonly find them in the fœtal state; and he had never felt any passion for women.

In this case, the testicles had been imperfectly formed, and the constitution was deprived of that influence which it naturally receives from them.

In addition to this imperfection in the organs of generation, he was weak in his intellects, and in his bodily strength.

The two following cases shew a still greater degree of imperfection in the male organs:—

A woman, near Modbury in Devonshire, the wife of a day-labourer, had three children; the first was considered to be an hermaphrodite, the second was a perfectly formed girl, and the third an hermaphrodite similar to the first.

Having heard this account, I visited the cottage in the year 1779, and made the following observations upon the imperfectly formed children:—The eldest was thirteen years of age; of an uncommon bulk, which appeared to be almost wholly composed of fat; his body, round the waist, was equal to that of a fat man, and his thighs and legs in proportion. He was four feet high; his breasts as large as those of a fat woman; the mons veneris loaded with fat; no penis; a preputium one-sixth of an inch long, and under it the meatus urinarius, but no vagina. There was an imperfect scrotum, with a smooth surface, there being no rapha in the middle; but, in its place, an indented line: it contained two testicles, of the size they are met with in the fœtus. He was very dull and heavy, almost an idiot, but could walk and talk; he began to walk at a year and a half old.

The younger one was six years old, uncommonly fat, and large for his age; more an idiot than the other, not having sense enough to learn to walk, although his limbs were not defective.

The external parts of generation differed in nothing from those just described, except the prepuce being an inch long. He had a supernumerary finger on each hand, and a supernumerary toe on each foot.

It is curious that the mother of these two children, so alike in their imperfections, should have a perfectly formed child

between them; and it leads me to mention, that the Polish dwarf, Count Boruwlaski, who came to England in 1786, and remains here, stated, that in his family the children had been alternately dwarfs; of which there were two, himself and his sister, the intermediate child having grown to the common size. He is eighty years old, and is expected in London to present to the King a history of his life written by himself.

The immense accumulation of fat, and the uncommon size of these children, accord with the disposition to become fat so commonly met with in the free-martin.

The species of malformation of the organs of generation, in which there is really a mixture of parts, or an evident attempt towards it, is less common than those we have mentioned.

Mr. Hunter has given several instances of it in the neat-cattle, where the mixture of male and female organs was in different degrees.

In two free-martins, imperfect testicles were found in the situation of the ovaria; and, in a third, an appearance like both testicles and ovaria was met with, close together, in the situation of the ovaria. He also gives the dissection of an hermaphrodite ass, in which there were substances resembling both testicles and ovaria in the abdomen.

Mr. Hunter never met with an instance of this kind in the dog; and I have not found one in any record which I have examined. I shall therefore state the following history of a case which has fallen under my own observation, as it proves that a mixture of the generative organs sometimes occurs in a species of animal in which it had not been before

met with; and, as the dog is more domesticated than almost any other quadruped, the occurrence must be rare indeed, otherwise it could not have escaped notice.

A favourite female dog of Lord Besborough's, which had lived in the family for many years, was observed to have no teats, and never to have been in heat, although, to appearance, a perfectly formed bitch in all other respects. Those circumstances being made known to Sir Joseph Banks, he requested that when the animal died it might be sent to him. This happened in the summer of 1798; and I had an opportunity of examining the organs of generation, which exhibited the following appearances:—There was not the smallest appearance of teats on the skin of the belly; so that, in this particular, it differed both from the male and female: nor was there the least trace of any thing like the gland of the breast under the skin. The clitoris was very large, being three-quarters of an inch long, and half an inch broad: the orifice of the meatus urinarius was unusually large, as if it was intended for a common passage to the bladder and vagina; so that the external parts were only the clitoris, the meatus urinarius, and rectum. Internally, in the situation of the ovaria, were two imperfectly formed small testicles, distinguished to be such by the convolutions of the spermatic artery; from these passed down an impervious chord, or vas deferens, not thicker than a thread, to the posterior part of the bladder, where they united into one substance, which was nearly two inches long, and terminated behind the meatus urinarius.

The other parts of the animal were naturally formed.

When the testicles were cut into, they appeared to have no regular glandular structure.

In this animal, the clitoris was the only part of the female organs that was completely formed.

What rendered the parts a decided mixture of male and female organs was, the testes being in the place appropriated for the ovaria, and the ligamentous substance, to which the vasa deferentia were connected, somewhat resembling an impervious vagina. The clitoris, in this instance, could not be considered as an imperfect penis, since the bone, the distinguishing mark of the dog's penis, was wanting.*

Mr. Brookes, teacher of anatomy, showed me, since these observations were made, a Newfoundland dog, in which there were testicles of nearly the usual size, and a vagina, but no penis; which is nearly the counterpart of what I have just described.

In Haller's account of hermaphrodites, before mentioned, there is the history of a kid, in which there was a mixture of male and female organs illustrated by an engraving. They were very similar to those of this dog: the imperfect testicles were in the same situation; but there was a pervious canal, or vagina, that divided, like the uterus, into two horns, which extended to the testicles: there were also vesiculæ seminales.

In the Memoires of the Royal Academy of Sciences in Paris, there is a very accurate description, by M. Petit, of a similar mixture of organs in the human species.

The person had wholly the character of a man, but was of a delicate constitution: he was a soldier, and died of his wounds. The appearance of the penis is passed over; but

* Plate CXVII.

the scrotum, not containing testicles, drew M. Petit's attention; and, in the dissection, he found testicles in the situation of the ovaria, attached to two processes, continued from an imperfect vagina, but having vasa deferentia, which passed in the usual manner to the vesiculæ seminales. The vagina communicated with the urethra, between the neck of the bladder and the prostate gland.

A case of mixed organs is mentioned in Dr. Baillie's Morbid Anatomy: the person was twenty-four years of age; had the breasts of a woman, and no beard. The clitoris and meatus urinarius had the natural appearance, but there were no nymphæ; and the labia pudendi were unusually pendulous, containing a testicle in each of them.

The vagina was nearly two inches long, and terminated in a blind end. She never menstruated; and had a masculine appearance.

This appears to have been the reverse of the case mentioned by M. Petit: in this the external parts were those of the female, in which were contained the testicles; while in the other, the internal parts were those of the female, with the testicles attached to them.

There is still another mixture of the organs of the female with those of the male, which must be considered the most rare in its occurrence; this is, an hermaphrodite bull, probably a free-martin, partaking so much of the bull as to have the male organs capable of propagating the species, and an udder capable of secreting milk.

A he-goat, that had been castrated in the island of Barbadoes, was sent home to me by the governor, Lord Seaforth: it arrived alive, and I saw it give milk; it soon after died.

The glands which secrete milk, although in themselves not organs of generation, entirely belong to them, and form a part of the female character sufficiently obvious to connect them intimately with the present subject.

That an animal, not a perfect female, should have glands which secrete milk, or indeed that an animal truly female, without having had young, should give milk, is so extraordinary, that even written evidence respecting it requires confirmation to entitle it to credit; in this respect, the following fact must be considered as perfectly satisfactory.

An instance of an hermaphrodite bull, whose udder secreted milk, occurred in Poland. The animal came into the possession of Mr. Brookes, who procured it near Grodno, in the year 1796, and carried it to St. Petersburgh, where it died in the following year; unfortunately, no examination was made after death.

While the animal was at St. Petersburgh, both Dr. Rogerson and Dr. Rogers had opportunities of examining it with a considerable degree of accuracy; and the following account is taken from their description, with which I have been favoured by Dr. Rogerson, who is now in London:—

The animal was under the usual size of neat-cattle, and is stated by Mr. Brookes to have been about fifteen years old: it was in a weakly state; and Mr. Brookes told Dr. Rogerson, that he had much difficulty in making it bear the journey from Grodno (a distance of about eight hundred miles), and was obliged to give it the most nourishing diet, which was principally ground malt.

In its general appearance, the male character predominated,

particularly in the head, horns, neck, shoulders, and organs of generation.

The flanks and hind quarters had a greater resemblance to those of the cow. The penis of the ordinary size, and had the common appearance; the preputium had the tuft of hair at the orifice, as in the bull.

The urine was ejected through the penis.

It had an udder in the common situation, which was smaller and more globular than that of the cow, and its teats were less pendulous.

Dr. Rogers found one of the testicles by pressing upon the udder, but was unable to detect the other.

There was an external orifice in the situation of the vagina; but so small as not to appear capable of receiving more than the point of the fore-finger.

Dr. Rogerson thinks that, from its appearance, it never could have admitted the male, much less have brought forth a calf; which had been asserted, but without any proof whatever.

Mr. Brookes, who is now in this country, admits that it had never received the male, or brought forth young, while in his possession; but asserts that it had several times covered the female, and had begot three calves. This assertion Dr. Rogerson thinks worthy of credit.

The udder contained milk capable of giving cream, but the quantity was very small.

When Dr. Rogerson was present, only an ounce could be procured; but he was told that at other times a tea-cup full was drawn. Mr. Brookes states, that he once saw an English pint milked at one time.

As the teats of the bull are in the same situation as those of the cow, it became an object of inquiry, whether any males of that tribe of animals, that were not hermaphrodites, had ever been known to give milk; and I find there are two instances recorded in the Philosophical Transactions of wethers having given suck.

One is upon the testimony of the Rev. Dr. Doddridge, who states that a lamb was nourished by the milk, and, when the teats were pressed, milk came out.

The other is on the testimony of Mr. Kirke of Cookridge, in Yorkshire. He mentions, that Sir William Lowther had a lamb suckled by a wether. The lamb sucked during the whole summer; and, after it was weaned, milk could be pressed from the teats: each side of the udder was the size of a hen's egg.

This account is dated twenty-eighth September, 1694: he gives a second relation, in November, stating that the udder was reduced in size, but there was still some milk in it, and no appearance of the animal being an hermaphrodite.

A case is also recorded in the Philosophical Transactions, of a man giving suck to a child two months old; this, however, is not stated with sufficient accuracy to allow any stress being laid upon it, although it would have been improper not to have noticed it in this place.

A young nobleman received a blow from a tennis-ball on the breast; in consequence of which, a lump formed in it. Upon consulting me, I found a glandular structure under each of his nipples; and the appearance and progress of the tumour induced me to apprehend that it might take

on the disposition for cancer. I was so strongly of this opinion that I performed the operation of extirpation. There has been in the course of ten years no return of the disease.

In considering the influence of the testicles upon the constitution of the male, which is rendered so evident by contrasting it with those cases in which the testicles are imperfect, it leads to a supposition that the ovaria may have a similar influence upon the constitution of the female, and that, when the ovaria are imperfectly formed, or when testicles are substituted for them, although the external parts are decidedly female, the person may grow up, deprived of that feminine character which the constitution would have acquired if the ovaria had been capable of producing their influence on the body.

To this cause may be attributed the unnatural bias which some women have shewn, to pass through life in the character of men.

The circumstance of some women, after the time of breeding is over, (at which period the influence of the ovaria may be considered as lost to the constitution,) approaching nearer to the male in appearance, and acquiring a beard; also the female pheasant, and duck, in several instances, at the same period of life, acquiring the feathers which distinguish the male, so as to be mistaken for males, is in favour of such an opinion. A pheasant was sent to me without spurs, smaller than the cock, but with the plumage of the male, much lighter however in colour: it proved to be a female, but had no yelk-bags begun to form. Another very similar instance was sent to me; both of them from Norfolk.

A gentleman has a hen five years old, the first plumage was black and white; the same after the first moulting; after the second, they were all white; after the third, all black; the fourth, all white: both black and white feathers are perfectly formed. The hen is unusually large, very prolific, but the eggs are deficient in shell, and never hatch.

The following account of a duck of this kind was sent to me by Mr. Rumball, surgeon, at Abingdon, in Berkshire.

The duck was bred by Mr. Cator, of Norwood, in Surry, in the year 1781. It continued to lay, and to hatch its young, till the year 1789; when the curled feathers, peculiar to the drake, made their appearance in its tail. From this period she not only left off laying, but frequently attempted to tread the other ducks, both in the water and upon the ground, and they courted her in return. This was particularly observed on the nineteenth of August, 1791, when she had a duck in the water, and fell off on her side as drakes usually do; and they both began washing themselves immediately after, as is customary on these occasions. She never afterwards suffered a drake to come near her.

Although the plumage changed, the voice continued the same, which is very different from that of the drake. This circumstance first attracted Mr. Rumball's notice, and made him doubt of its being really a drake.

On the fourth of October, 1793, at the request of Mr. Rumball, this duck was sent to Mr. Hunter, and died on the eighteenth, two days after Mr. Hunter's death. On examination, the organs of generation were those of a perfect duck. The skin is stuffed, and preserved in the Hunterian collection.

The histories of monsters which have superfluous parts, as that of the child with the double head, (with an account of which I shall finish the present Lecture,) and all others of the same kind, led to the opinion of two or more fœtuses having been contained in one ovum, similar to two yelks in one egg; and that, from circumstances having taken place in utero, certain parts of one of the fœtuses were prevented from coming to perfection, and were absorbed; while those that remained became connected to the other fœtus. This was the opinion I entertained before I was acquainted with the human ovum: I am now clear that it must happen in another way:—that is, two ova being impregnated in one ovarium, passing along the same Fallopian tube, having been so pressed on each other, that when they arrived at the the uterus they were imbedded in one common covering from the uterus, and under these circumstances one had been rendered imperfect.

The testicles being substituted for the ovaria, and the ovaria themselves entirely wanting, is probably the most curious circumstance that is met with in the structure of hermaphrodites; and, as many important discoveries in the animal economy have been suggested from the examination of monstrous productions, it naturally leads to the inquiry, whether there is any thing in the original formation of the parts that can account for so strange an occurrence.

The only mode in which it can be explained, as far as I am able to judge, appears to be the following:—By supposing the ovum, in its origin, to have no distinction of sex, but to be equally fitted to become a male or female fœtus; and that at some period, either before impregnation, or at

that time it acquires its character, the same materials becoming testicles or ovaria.

The following circumstances are in favour of this opinion, The testicles and ovaria are formed originally in the same place, although the testicles, even before the fœtus has advanced to the eighth month, are to change their situation to a part at a considerable distance.

The clitoris, in fœtuses under four months, is so large as to be often mistaken for a penis.

Preparations to show the size of the clitoris at this age are preserved in the Hunterian collection; and M. Terrien mentions it, with a view to explain an erroneous opinion which prevailed in France, that the greatest number of miscarriages between three and four months have been remarked to be males; which mistake arose from the above circumstance.

The clitoris, originally, appears therefore equally fitted to be a clitoris or penis, as it may be influenced by the ovarium or testicle.

In considering this subject, it is curious to observe the number of secondary parts, which appear so contrived that they may be equally adapted to the organs of the male or female.

In those quadrupeds whose females have mammæ inguinales, the males have also teats in the same situation; so that the same bag which contains the testicles of the male is adapted to the mammæ of the female.

In the human species, which have the mammæ pectorales, the scrotum of the male serves the purpose of forming the labia pudendi of the female, and the preputium makes the

nymphæ. The male has pectoral nipples, as well as the female; and, in many infants, milk, or a fluid analagous to it, is secreted, which proves the existence of a glandular structure under the nipple.

This circumstance, when added to the instances already related, of an hermaphrodite bull, and of wethers giving suck, affords a strong presumption that the rudiments of the mammæ exist in the males, and in some few instances have been brought to perfection, either by an original mixture of organs, early emasculation, or other changes, with which we are at present unacquainted.

It is a curious circumstance, which I learnt from Sir Joseph Banks, that in those vegetables whose male and female organs are in distinct flowers, if the male organs are removed at an early stage of their growth, female organs appear in their place, which led one of our best botanical physiologists to believe that he could convert the male and female organs into one another; till Sir Joseph Banks explained to him that this provision of nature was readily proved in the cucumber, that in case of any accident happening to the original organs, there were dormant ones of the opposite sex ready to appear, but which otherwise did not come forward.

If it is allowed that the sex is impressed upon the ovum at the time of impregnation, it may in some measure account for the free-martins occurring when two young are to be impressed with different sexes at one impregnation; which must be a less simple operation, and therefore more liable to a partial failure, than when two or any greater number of ova are impressed with the same sex.

It may also account for twins being most commonly of the same sex; and, when they are of different sexes, it leads us to inquire whether the female, when grown up, has not, in some instances, less of the true female character than other women, and is not incapable of having children.

In warm countries, nurses and midwifes have a prejudice, that such twins seldom breed.

This view of the subject throws some light on those cases where the testicles are substituted for the ovaria; since, whenever there is a failure in stamping the ovum with a perfect impression of either sex, the organ formed will neither be an ovarium nor a testicle, sometimes bearing a greater resemblance to the one, sometimes to the other; and may, according to circumstances, either remain in the natural situation in which the testicle and ovarium is formed, or descend into the scrotum of the male, or the labia pudendi of the female.

The child with a double skull was born in May, 1783, of poor parents; the mother was thirty years old, and named Nooki; the father was called Hannai, a farmer in Mundulgaut, in the province of Bengal, and aged thirty-five. The mother declared to Mr. Dent, that there was nothing particular during pregnancy, either in dreams or fright.*

At the time of the child's birth, the woman who acted as midwife, terrified at the strange appearance of the double head, endeavoured to destroy the infant by throwing it upon the fire, where it lay a sufficient time before it was removed to have one of the eyes and ears considerably burnt.

* Plates CXVIII. CXIX. CXX. CXXI.

The body of the child was naturally formed, but uncommonly thin, appearing emaciated from want of due nourishment; but the head appeared double, there being besides the proper head of the child another of the same size, and to appearance almost equally perfect, connected to its upper part. This upper head was so attached that they seemed to be two separate heads united together by a firm adhesion between their crowns, but with a considerable indentation at their union; however, the surface from the one to the other was smooth. The face of the upper head was not over that of the lower, but had an oblique position, the centre of it being immediately above the right ear.

When the child was six months old, both of the heads were covered with black hair, in nearly the same quantity.

At this period the skulls seemed to have been completely ossified, except a small space between the ossa frontis of the upper one, like a fontinelle.

No pulsation could be felt in the situation of the temporal arteries of the upper head; but the superficial veins were very evident.

The neck was about four inches long, and it terminated in a rounded hard gristly tumour, nearly four inches in diameter.

One of the eyes had been considerably burnt by the fire; the other appeared perfect, but dim, having its full quantity of motion; the eye-lids were not thrown into action by any thing suddenly approaching the eye; yet when exposed to a strong light, it contracted, although not so much as it usually does. The eyes did not correspond in their motions with those of the lower head; they appeared often to be

open when the child was asleep, and shut when it was awake.

The external ears were very imperfect, being only loose folds of skin; and one of them mutilated by having been burnt. There did not appear to be any passage leading into the bone which contains the organ of hearing.

The lower jaw was rather smaller than it naturally should be, but was capable of motion.

The tongue was small, flat, and adhered firmly to the lower jaw, except from about half an inch at the tip, which was loose.

The gums in both jaws had the natural appearance; and the front teeth were seen both in this head and in the other.

The internal surfaces of the nose and mouth were lubricated by the natural secretions, a considerable quantity of mucus and saliva being constantly discharged from them, and equally from both.

The muscles of the face were evidently possessed of powers of action, and the whole head had a good deal of sensibility; since violence to the skin sometimes produced the distortion expressive of crying, and thrusting the finger into the mouth made it show strong marks of pain. When the mother's nipple was applied to the mouth, the lips attempted to suck.

The natural head had nothing uncommon in its appearance; the eyes were attentive to objects, and its mouth sucked the breast vigorously. Its body was emaciated.

The parents of the child were poor, and carried it about the streets of Calcutta as a curiosity, to be seen for money;

and to prevent its being exposed to the populace, they kept it constantly covered up, which was considered as the cause of its being emaciated and unhealthy.

The attention of the curious was naturally attracted by so uncommon a species of deformity, and Mr. Stark, who resided in Bengal during this period, paid particular attention to the appearances of the different parts of the double head, and endeavoured to ascertain the mode in which the two skulls were united, as well as to discover the sympathies which existed between the two brains.

At the time Mr. Stark saw the child, it must have been nearly three years old; the molares, or double teeth, which usually appear at twenty months, or two years of age, were through the gums. This was some months before its death, which happened in May, 1786.

At this time the appearances differed in many respects from those taken notice of when six months old.

The burnt ear had been entirely destroyed.

The openings from the external ear appeared as distinct as in those of the other head.

The skin surrounding the injured eye, which was on the same side with the mutilated ear, was in a slight degree affected, and the external canthus much contracted, but the eye itself was perfect.

The eye-lids of the superior head were never completely shut, remaining a little open, even when the child was asleep, and the eye-balls moved at random. When the child was roused, the eyes of both heads moved at the same time; but those of the superior head did not appear to be directed to the same object, but wandered in different directions.

The tears flowed from the eyes of the superior head almost constantly, but never from the eyes of the other, except when crying.

The termination of the upper neck was very irregular, a good deal resembling the cicatrix of an old sore.

The superior head seemed to sympathise with the child in most of its natural actions.

When the child cried, the features of this head were not always affected.

When it sucked the mother, satisfaction was expressed by the mouth of the superior head, and the saliva flowed more copiously.

When the child smiled, the features of the superior head did not sympathise in that action.

From the father's account, when the child was in perfect health, the mother went out to fetch some water; and upon her return found it dead, from the bite of a cobra de capello snake.

The body was buried near the banks of the Boopnorain river. It was afterwards dug up by Mr. Dent's direction, the religious prejudices of the parents not allowing them to dispense with its being interred.

My friend, Captain Buchanan, late commander of the Ranger packet, in the service of the Honourable the East India Company, when at Bengal, resided a few days in Mr. Dent's house. He was much struck with the uncommon appearance of the double skull, and expressed a wish that he might be allowed to bring it to Europe and present it to me; knowing, from the interest I have always taken in

those pursuits which have so long and so deeply engaged my attention, it would be a most acceptable present.

His request was no sooner communicated to Mr. Dent than it was complied with; that gentleman having too much liberality to hesitate a moment in sending so rare a curiosity to Europe.

The mode in which the two skulls are united is curious, as no portion of bone is either added or diminished for that purpose; but the frontal and parietal bones of each skull, instead of being bent inwards, so as to form the top of the head, are continued on; and, from the oblique position of the two heads, the bones of the one pass a little way into the natural sutures of the other, forming a zig-zag line, or circular suture uniting them together.

In attempting to clean the skull, the dura mater was found to be continued across, so as to form a septum between the two brains.

It was double, and a number of vessels passed through it, from one brain to the other.

The two skulls appear to be almost equally perfect at their union; but the superior skull, as it recedes from the other, is becoming somewhat imperfect and deficient in many parts.

The meatus auditorius in the temporal bone is altogether wanting.

The basis of the skull is imperfect in several respects, particularly in all such parts as commonly connect the skull with the body.

The foramen magnum occipitale is a small irregular hole, very insufficient to give passage to a medulla spinalis; round

its margin are no condyles with articulating surfaces, as there were no vertebræ of the neck to be attached to it.

The foramen lacerum in basi cranii is only to be seen on one side, and even there too small for the jugular vein to have passed through.

The ossa palati are deficient at their posterior part; the lower jaw is too small for the upper, and the condyle and coronoid process of one side are wholly wanting.

In other respects the two skulls are nearly alike.

Mr. Dent, in preparing the skull, found the number of teeth to be sixty. He also found a dura mater belonging to each brain continued across, at the part where the two skulls joined, so that each brain was invested by its own proper coverings; the dura mater, however, which covered the cerebrum of the upper brain, adhered firmly to that of the lower; the two brains were therefore separate and distinct, having a complete partition between them.

When the contents of the double skull were taken out, and this partition more particularly examined, a number of large arteries and veins were seen passing through it, making a free communication between the blood-vessels of the two brains. This is a fact of considerable importance, as it explains the mode in which the upper brain received its nourishment.

The specimen is preserved in the Museum of the College.

LECTURE XII.

On the Mode of Breeding of the Kangaroo, Opossum, and Ornithorhynci.

The animals whose mode of generation I am about to describe form two distinct classes, both of which are intermediate between that already described, in which the placenta adheres to the uterus, and the bird in which the uterus is altogether wanting. One of these classes is composed of animals whose young are viviparous; the other of animals truly oviparous.

They fill up the chasm in the great connecting chain of nature, by forming two links which unite the quadruped to the bird.

The first of these classes consists, as far as we yet know, of only three orders, the kangaroo, the koala, and opossum: the second class, of only two, the ornithorhyncus paradoxus and ornithorhyncus histrix.

I shall begin by describing the organs of generation of the kangaroo, which belongs to the first order of the first of these classes.

Twenty-six years ago, I examined the generative organs of this animal; but as at that period the most skilful anatomists had not succeeded in fully exploring the process of generation to its origin in the quadruped, I stumbled in the threshold, and although acquainted with the anatomical structure of the female organs, I was unable to explain a variety of circumstances in which the generation of this animal differs from that of quadrupeds.

I at that time examined the penis of the male, and thought I had done so under the most favourable circumstances, the animal being the largest ever seen in England, in full health, lying basking in the sun in Richmond gardens, with what appeared to be a complete erection. I described what I saw, and stated that although the animal is retromingent, the penis comes forward and terminates in a small point, there being no prepuce. This description has from that time remained uncontradicted; but in preparing myself for these Lectures, and reconsidering the subject of the kangaroo's mode of generating its young, I could not feel satisfied that the point of the penis is really single, since in all the other orders of the same class it is double.

I therefore took advantage of an opportunity that offered of examining these parts with more attention; there being a young male kangaroo in the menagerie at Exeter Change, in London.

With the assistance of one of Mr. Cross's men I threw the animal on its back, and making fast its feet, brought the male organ distinctly into view: just before the erection was rendered complete, the appearance was the same as I had seen before; but in the endeavour to excite the parts still more, the

point opened, and proved to be the orifice of the prepuce, which fell back, and two delicately formed processes of a very bright red colour were brought to view; the orifice of the urethra lay between them, with a groove extending to the point of each. They were half an inch long, and bore an exact resemblance to the double tongue of the snake.

From this mechanism it will be found that, in the act of copulation, the double glans is not denuded till the penis has arrived at the end of the vagina, being too delicate to bear the resistance of the more external parts.

The testicles are pendulous, hanging in a scrotum with a narrow neck, a little before the common opening of the anus and the passage for the penis.

In the female, the organs of generation do not appear externally, there being one common opening surrounded by cuticle covered with hair; for both the vagina and rectum, and the two canals, are separated from one another by means of a septum of no considerable thickness.

The common orifice is projected beyond the bones of the pelvis above two inches, and this prominent portion admits of considerable motion.

In giving an anatomical description of the female organs of the kangaroo, I shall, with a view to avoid unnecessary detail, describe them, first in their natural or unimpregnated state, and afterwards take notice of the changes they undergo during pregnancy, and after parturition.

At the external orifice of the vagina is situated the clitoris, which, when compared with the other parts, may be said to be large; it is inclosed in a preputium; a little way farther on in the vagina are two orifices, the openings of the ducts of

Cooper's glands. The vagina itself is about an inch and a half in length, beyond which it leads into two lateral canals; and on the edge formed between them opens the meatus urinarius, leading to the urinary bladder.

These canals are extremely narrow for about a quarter of an inch in length, and at this part their coats are very thick; they afterwards become more dilated and membranous; they diverge in their course, and pass upwards for nearly four inches in length; they then bend towards each other, so as to terminate laterally in the two angles of the fundus of the uterus.*

The uterus is extremely thin and membranous in its coats, slightly infundibular in its shape, and situated in the middle line between the two canals.

In the virgin state it is impervious, so that at that time there is no communication with the vagina except by the lateral canals.

The same internal membrane that lines the lateral canals appears to line the uterus; it is thrown into folds equally so in the uterus and canals, and a broader fold than the rest marks a division of the uteres into two equal parts.

The ovaria and fimbriæ resemble those of quadrupeds; the Fallopian tubes follow nearly the same course to the uterus as in the quadruped; but a little way before they reach it, they dilate considerably, forming an oval enlargement, the coats of which are much thicker than those of the other parts, and the supply of blood-vessels much greater, so that there is no doubt of its performing some peculiar office beyond this part, the tubes contract and

* Plate CXXII.

pass perpendicularly through the coats of the uterus at its fundus, and terminate in two projecting orifices, one on each side of the middle ridge just mentioned.

The ovaria in the kanguroo are similar to those of quadrupeds in general; have corpora lutea produced in them, and in these the ova are formed. I got Mr. Bauer to examine them in a microscope. When magnified four diameters the appearance of the structure of the corpus luteum is beautifully distinct.*

From these examinations it would appear that commonly the kanguroo has only one young at a time, for although in one ovarium there are the rudiments of two corpora lutea, they are in different degrees of advancement.

It is evident that both ovaria are forming corpora lutea at the same time, but they are in very different stages.

As the ovum in this animal is not afterwards to be attached to the uterus, there can be no doubt that the thickened oval portion of the Fallopian tube, near its termination in the uterus, which extends to the depending orifice, is to supply something analogous to yelk, which is to attach itself to the ovum before it drops into the cavity; it is afterwards supplied by albumen from the internal surface of the two lateral tubes, in the same manner as albumen is formed in the oviducts of birds.

The structure of the coats of the oval enlargement of the Fallopian tube is of a very uncommon kind; it does not resemble any known gland in the body employed for secretion: the yelk I shall prove in the course of these Lectures, from experiments of my fellow-labourer in Animal

* Plate CXXVI.

Chemistry, Mr. Hatchett, is oil or fat in a most exceedingly concentrated state; and I have already endeavoured to support an opinion that fat and oil are not secretions. I have considered them to be formed in the intestine generally, but in some animals in the liver, and after being received into the circulation, deposited by the terminations of arteries whenever wanted. Nothing can better accord with this idea than the apparatus set up in the Fallopian tube: there is an arterial trunk at some distance of considerable size, which sends off an infinite number of branches, all nearly of the same length, and all terminating in this oval portion of the tube. This is perhaps the only structure to be met with of the kind, probably also the only occasion in which concentrated oil is required to be suddenly collected.*

When the ovum arrives at the uterus it is enveloped in an abundant quantity of albumen; this I have had an opportunity of seeing. There was nothing like shell, and the soft ovum had been too long preserved in spirit to retain its natural appearance; it was reduced to a pulp. The uterus and the lateral tubes were filled with this jelly, and the os tincæ plugged up with it; the lateral tubes were open into the vagina. In the cavity of the uterus, in the midst of this coagulated jelly, was a small portion of the rudiments of a fœtus.†

I had an opportunity, in the year 1794, of reading these observations to Mr. Considen, who was seven years an assistant surgeon to the General Hospital, New South Wales. He had paid attention to this subject; and during his resi-

* Plate CXXIII. † Plate CXXIII.

dence in that country, he met with the uterus of the kanguroo three times in a state of enlargement: the degree of distension was nearly the same; the gelatinous matter, examined immediately after death, was of a bluish white colour, in consistence like half-melted glue, and so extremely adhesive as to be with difficulty washed off from the fingers. The internal membrane of the uterus was very vascular, even more so than that of the lateral canals.

This account of these organs was drawn up in 1795. Since that time, my knowledge of this subject is much enlarged; and although I was then unable to make out satisfactorily in what manner impregnation took place, I have now no doubt that the semen is conveyed into the uterus through the two lateral canals, and is there applied to the albumen in which the molecule corresponding to the human ovum is enveloped, and the embryo is afterwards aerated by means of the atmosphere through the openings into the lateral canals from the vagina.*

How long it requires for the ovum to be hatched in utero is not even at this day ascertained; whenever that happens, the young is propelled into the marsupium through the os tincæ which opens for that purpose. There it becomes attached to the point of the nipple.

The mammæ are two in number; each of them has two nipples; they are not placed upon the abdominal muscles, as in other quadrupeds, but are situated between two moveable bones connected to the os pubis, and the mammæ are supported upon a pair of muscles which arise from these bones and unite in the middle between them.

* Plate CXXV.

These mammæ are covered anteriorly by the lining of the false belly, and the nipples project into that cavity; this covering is similar to the external skin, having a cuticle, and short hair thinly scattered over its surface, except at the root of the nipples, where there are tufts of some length, one at the basis of each.

The mammæ are supplied with blood from the epigastric arteries. The mammary branches run superficially under the false belly till they reach the mammæ. There is a strong muscle which comes down from the upper part of the abdominal muscles, and adheres firmly to each of the mammæ; this prevents the gland from being dragged from its natural situation while the young is sucking.

The two bones that lie behind the mammæ deserve a particular description, as they are met with in the whole tribe that have false bellies, and are not even peculiar to them, in some degree belonging to other animals, as the crocodile: they go to the mammæ, and have no other use but what is connected with the motion of these parts.

They are about two inches and a half long, are flattened, and at their broadest part measure nearly half an inch: they are attached to the projecting part of the os pubis, which is fitted for that purpose, just before the insertion of the recti muscles; this attachment to the pubis is by a very small surface, and admits of considerable motion. They have likewise a connection, by a ligament half an inch in breadth, to the ramus of the pubis which joins the ilium. From their base, which is united to the pubis, they become narrower till they terminate in a blunted point. These bones have a pair of muscles inserted into their base, to

bring them downwards and outwards; another pair is connected to their blunted extremities, to bring them forwards; a pair of broad flat muscles fills up the whole space between them, arising from their inner edge through its whole length; these last serve as a sling to support the mammæ, and also to bring the bones towards each other.

Besides these additional bones, and the projection to which they are attached, there is another peculiarity in the structure of the pelvis of the female: the two rami of the os ischium, which join the pubis, have no notch between them, as in other quadrupeds, but form a round convex surface of some breadth, projecting considerably forwards. The surface itself is smooth, like those over which tendons pass; but the lateral parts are rough, and have a pair of muscles arising from them, inserted into the skin of the false belly, to bring its mouth towards the pudendum.

The mode in which the young passes from the uterus into the false belly has been matter of much speculation; and it has even been supposed that there was an internal communication between these cavities; but after the most diligent search, I think I may assert no such passage exists. This idea took its rise from there being no visible opening between the uterus and vagina during impregnation; but such an opening remaining of some size after parturition explains the mode in which the young passes out; and the false belly or bag having muscles, which must, when they are in action, bring both the orifice and the mammæ themselves close to the vulva, removes all the theoretical objections against the young getting to the nipple; particularly as the vulva has naturallyan unusual projection, and the

margin of the pelvis immediately before it is rounded and smooth, so as to admit of its moving easily in that direction. The very action of opening the mouth of the false belly, by bringing down the skin, will allow the external orifice of the vagina to be thrown still further out, so as to project more directly over the mouth of the false belly in which the fœtus is to be deposited.

It is to be observed, that as all these circumstances belong to the parts in a natural state, they will be much increased at the period at which parturition takes place; since in all animals, at that particular time, there are changes going on to facilitate the expulsion of the young in the way most favourable for its preservation.

The size of the young at this period is not exactly known, since no one has yet had an opportunity of seeing it, but there can be no great error in fixing it at the weight of twenty-one grains, and an inch long without the tail, since I have procured one of that size, and the point of the nipple had not entered the mouth, but was simply glewed to the lips, probably by the very adhesive gelatinous substance contained in the uterus.* Its fore-paws were tolerably well formed, and double the length of the hind ones. There was no appearance of any vestige of a navel-string.

When the young is first attached to the nipple, the face appears to be wanting, except a round hole at the muzzle to which the nipple is applied and adheres; soon after, the lips and jaws grow upon the nipple, till at last nearly half an inch of its length is inclosed in the mouth.

* Plate CXXIV.

It may be an advantage to my audience, after having thus explained the peculiarities of the structure of the organs of generation, to point out the resemblance its mode of propagation bears to the quadruped on the one hand, and to that of the opossum tribe on the other. It resembles quadrupeds in general in the corpus luteum generated in the ovarium producing the ovum, in all other respects it differs, the ovum not having any attachment to the uterus, and consequently no navel-string. When the young is actually brought forth, sucking the mother becomes another point of resemblance to the quadruped. In all other points except the oval enlargement of the Fallopian tube, which is peculiar to it, there is a near but not a close alliance to the opossum.

There is, in New Holland, a large prehensile tailed opossum with a small marsupium, in no respect resembling the kanguroo in its external appearance, nor in its stomach, which is exactly the same as that in the American opossum; but the form of its uterus and lateral canals is the same as in the kanguroo; it must therefore stand in a separate order of marsupial animals, in all general systems formed upon their external appearances; but in the system I shall bring forward, it, strictly speaking, is of the same order with the kanguroo.

It must, however, be considered as a different tribe of animals; and therefore I shall call all such of the second tribe.

A third tribe of animals, whose organs of generation I am to describe, belongs as well as the kanguroo to New Holland, and the female has a marsupium in which the nipples are

inclosed. There are two species of this animal, one called the wombat, the other the koala. A male wombat was brought from the islands in Bass's Straights, by my friend Mr. Brown the naturalist, who was attached to Captain Flinder's voyage of discovery. He kindly presented it to me. It lived in my house for two years, and was so much domesticated, that its habits admitted of being attentively examined.

It burrowed, and covered itself under ground very quickly. It was quiet in the day, but constantly in motion during the night; was very sensible to cold, ate all kinds of vegetables, was particularly fond of new hay, taking it into its mouth by small bits at a time like the beaver; was not wanting in intelligence, and appeared attached to those with whom it was acquainted and were kind to it; would put its fore-paw upon their knee, and would sleep in their laps.

It allowed children to carry it about, and never bit them in anger. It appeared full grown; was two feet two inches long; weighed twenty pounds.

The other species is the koala. Of this animal I received the following account from my late friend, Col. Paterson, lieutenant-governor of New South Wales. It inhabits the forests of New Holland, about fifty or sixty miles to the south-west of Port Jackson.

It is commonly two feet long and one high. It is covered with fine soft fur of a lead colour on the back, white on the belly. The ears are short, erect, and pointed; the eyes generally ruminating, sometimes fiery and menacing. It bears a great resemblance to the bear in the fore-part of the body; has no tail. Its usual posture is sitting.

The New Hollanders eat the flesh of this animal, and therefore readily join in the pursuit of it. They examine, with wonderful rapidity and minuteness, the branches of the loftiest gum-trees. Upon discovering the koala, they climb the tree in which it is seen, with as much ease and expedition as an European would mount a tolerably high ladder. Having reached the branches, which are sometimes forty or fifty feet from the ground, they follow the animal to the extremity of a bough, and either kill it with the tomahawk or take it alive. The animal feeds upon the tender shoots of the blue gum-tree, being fonder of this than of any other food. It rests during the day on the tops of these trees, feeding at its ease or sleeping. In the night it descends and prowls about, scratching up the ground in search of some particular roots. It seems to creep rather than walk. When incensed or hungry, it utters a long shrill yell, and assumes a fierce and menacing look. They pair, and the mother carries the young on its shoulders.

This animal seems soon to form an attachment to its feeder.

In both of these tribes, the male has a double point to the penis; and the female organs are alike in both.

They differ from the kanguroo, there being two uteri, and only one ovarium and Fallopian tube to each; but there is no swell or enlargement of the tube near the uterus, and at the termination of the vagina, there is only one lateral tube to each uterus for receiving the semen of the male.

These lateral tubes do not extend, as in the kanguroo, to the fundus of the uterus; but pass immediately from the vagina to the uterus, just within the os tincæ, describing nearly a semicircular course.

When copulation takes place, the point of the penis being double, there is always an equal chance of both uteri being impregnated; but their being so is not necessarily the case: and one ovarium only may have an ovum ready for the male influence, and before the ovum already impregnated is hatched, the other uterus may have received an ovum which may be impregnated by another copulation, as the os tincæ of the uterus, after the young is ready to pass into the marsupium, opens for that purpose. The ova are aerated through these lateral tubes.

In the wombat, the ovaria do not form corpora lutea, as in the kanguroo, but yelk-bags. These are, however, so compact, and so completely imbedded in the substance of the ovarium, that to all external appearance they resemble those of the quadruped; and till Mr. Bauer's microscopical observations were made upon them, this difference could not be satisfactorily discovered.

I have had no opportunity of seeing the uterus in the wombat tribe in a state of impregnation; but a surgeon upon the East India Company's establishment of great promise, Mr. Bell, had that opportunity, and afterwards died. As he was a *protégé* of Sir Joseph Banks, his papers were sent to England; and Sir Joseph put those upon this subject into my hands. The following is Mr. Bell's statement:—

" On laying open the cavity of the pelvis, I was surprised " by the appearance of a double uterus, each of them dis- " tended into a pyramidal form: that of the right side was " considerably the largest, and about the size of a pullet's " egg. From the fundus of each there was a Fallopian tube " nearly three inches long, terminating at the fimbræ.

" The double uterus had one common neck half an inch

" long, and of considerable breadth and thickness. Two " lateral canals rose from the common neck, on its posterior " surface, near the junction to the uteri, one on each side; " they were about two inches long, having a semicircular " course, and terminated obliquely in the vagina.

" The uteri and their appendages were dissected out from " the body, for more particular examination.

" On opening the vagina, it was found to terminate at the " common neck of the uteri, on each side of which were the " openings of the lateral canals; and in the middle between " them the meatus urinarius, with a fleshy pedicle on each " side of it. Behind the meatus were two orifices leading to " the two uteri; but these were filled with a thick gelatinous " substance, which rendered them completely impervious.

" I made a longitudinal incision into one of the uteri which " appeared larger than the other, and found its coats lined " with the same jelly met with in the os tincæ; continuing " the incision through the jelly, and at the same time using " gentle pressure, there issued out an embryo, no part of which " was connected to the uterus. The other uterus appeared to " me to contain an embryo of less dimensions, but it was not " examined."

The wombat having a marsupium, and marsupial bones, as in the kanguroo, the young are of course propelled from the uterus in the same manner, and become attached to the point of the nipple.

The penis of the wombat and koala differs from that of the kanguroo materially; the glans is tumid, oval, and covered with prickles, which are bent back and hooked at the end; it terminates in a transverse groove, at each end of which

there is a projection: these prominent points are rough; the urethra in the middle of the glans opens into the groove, as it were sending off two branches, one to each of the lateral canals of the female, the middle space being opposed to the two ossa tincæ of the uteri.

The prostate gland resembles exactly that of the kanguroo, and is proportionably large.

A fourth tribe of animals belonging to this class, which I have to describe, does not belong to New Holland, but to North America: of these there are different species; some much larger than others. All of them resemble the wombat in the same general principle, only that the uterus is single, and the Fallopian tubes, as well as the lateral canals, double: these last open into the uterus immediately within the os tincæ.

In the wombat, and the different species of the opossum, the ovaria, externally, have the same general appearance; at least, after the parts have been preserved in spirits, the one is not to be distinguished from the other. This is so entirely the case with respect to their internal structure, that Mr. Bauer, when they were placed before him, could find no material distinction between them, either in their internal or external structure.*

The next class of animals whose organs of generation I am to describe, consists of two tribes, called Ornithorhynci; and as the animals are so very extraordinary, both in their form and habits, I shall mention all the particulars respecting them that were not noticed in my former Lectures, in which the teeth and digestive organs are taken notice of. The first tribe, paradoxus, is an inhabitant of the fresh water lakes in New South Wales: when full grown, the male

* Plate CXXVII.

is larger than the female. The following account of them I received from Captain Hunter, who was Governor of the Colony:—

It does not swim upon the surface of the water, but keeps the point of its bill above it, for the purpose of breathing: the natives sit upon the banks, with small wooden spears, and watch an opportunity of striking them; which they do with much dexterity.

Governor Hunter saw a native watch one for above an hour, before he attempted to spear it; which he did through the neck and fore-leg: when on shore, the animal used its claws with so much force, that they were obliged to confine it between two pieces of board, while they were cutting off the barbs of the spear to disengage it.

As there are several engravings of this animal before the public, it will not be necessary to give an account of its external appearance.

The hair is made up of two kinds; a very fine thick fur, half an inch long, and a very uncommon kind of hair, three-fourths of an inch long. The portion next the root has the common appearance of hair; but at the point it becomes flat, giving it some faint resemblance to very fine feathers: this portion has a gloss upon it; and when the hair is dry, the different reflections from the edges and surfaces of these longer hairs give the whole a very uncommon appearance. The fur and hair upon the belly is longer than that upon the back.

Externally, there is no appearance of organs of generation in either sex; the orifice of the anus being common to the rectum and penis in the male, and to the rectum and vagina in the female.

After the most accurate scrutiny, even where the hair had been entirely separated, there was not the slightest appearance of nipples.

The ribs are sixteen in number: six attached to the sternum, which is narrow and very moveable; the other ten terminate anteriorly, in broad, flattened, oval, bony plates, which overlap each other in the contracted state of the chest, and are united together by a very elastic ligamentous substance, which admits of their being separated to some distance; so that the capacity of the chest can undergo a very unusual degree of expansion and contraction.*

The ribs are not connected to the sternum by cartilages, as in quadrupeds, but by bone: there is a cartilaginous portion, about an inch long, dividing the rib into two, and forming a kind of joint: there is no ensiform cartilage.

The male is distinguished from the female by no other external appearance than the spur, which is attached to the heels of both the hind-feet: it is half an inch in length, with a sharp point. There is a joint between the spur and the heel, admitting of motion in two directions: one that brings it in towards the body, in which state it lies concealed; the other throws it onwards, and renders it very conspicuous.

These spurs Sir John Jameson, resident in New South Wales, who has the opportunity of examining the parts in a recent state, declared to be tubular, and gave to the Linnæan Society a paper on that subject some years ago; he also mentioned that some of the natives, who had been wounded by them, asserted that they emitted a liquor of a poisonous nature. In examining the parts, after being long kept in spirits, no such structure was met with; and when the spurs were

* Plate CXXVIII.

boiled, the cavity appeared to be similar to that of the cock, only filled with a pulp instead of a core: this, however, I have since found, is an artificial appearance, the effect of coagulation. Upon examining the spur in a state of better preservation, I not only find a membranous tube passing through the spur, which has an orifice on one side, near the point; but Mr. Clift succeeded, in my presence, in injecting a duct leading to a gland which lies across the back part of the thigh, over the muscles, one inch and more in length, and half an inch broad: the excretory duct passes like the ureter of the kidney, out of one side, near the middle. The quicksilver injected immediately pervaded every part of the gland; and when the point of the pipe was turned downward, ran readily to the root of the spur, where the duct made a turn, and formed a small reservoir. After a little time, however, the mucus being gently squeezed, and pressed forward, we saw the mercury in the spur, and at last it came out of the orifice.

When I first saw the spur, I had no doubt from its situation but that one of its purposes was to prevent the escape of the female during the act of the coitus: in this I was confirmed when I found in the female, exactly in the same situation, a regular socket, lined with strong cuticle, adapted to the reception of the spur. This evident use led me off from making further enquiry, till I was urged by Sir John Jameson so to do.

Contrivances for holding the female during the coitus are not uncommon. In the toad and frog, the fore-legs of the male are applied round the belly of the female for that purpose. In the shark, there are regular holders, as will be shown. In the earth-worm, it is effected by suction, as will

be explained. In the dytiscus marginalis, an insect that copulates under water, there is an apparatus mentioned in the seventh Lecture, more nearly allied than any other to the present apparatus; on the thigh of the male there are suckers which attach the animal to the female.

Having ascertained that a secretion is emitted through the spur of the male into this socket, and the parts being so minute as to require glasses of considerable power, I got Mr. Bauer to examine the socket in the female; and after overcoming considerable difficulties, the parts being very much corrugated, and yet retaining their elasticity, he made out the form of this socket, which corresponds exactly in shape with the spur itself; so that when completely introduced, it must be so grasped that the male would be unable to withdraw it when the coitus was over; in this respect resembling the effect of suction. The male, it would appear, at least this is the best conjecture that I can make by reasoning from analogy, there being no facts to guide us, by throwing some of the secretion of the gland in the thigh into the socket, dilates it, and releases the spur: the liquor injected being acrimonious, will also irritate the female, and make her use efforts to escape. This is exactly similar to what is performed in the cupping-glass apparatus by muscular action, to let in the air.

The testicles are situated in the cavity of the abdomen, immediately below the kidneys; they are large, for the size of the animal. The epididymis is connected to the body of the testicle by a broad membrane, which admits of its lying very loose. The penis of the male has a structure of so extraordinary a nature, that unless I was able to illustrate it by a drawing, my veracity might be questioned; and indeed

it has been examined by other anatomists where the parts were not preserved in a perfect state, and some of the most incredible peculiarities were overlooked. In justice to those anatomists, I confess, that my first examination failed from the same cause; but fortunately I had the opportunity of repeating it on more perfect specimens, and was able clearly to make out the whole of this remarkable structure. The first extraordinary circumstance is the urine not passing along the urethra of the penis; it is conducted by a distinct canal which opens into the rectum, an inch above the external orifice of that gut. On each side at this part is a large solid body, the size of a testicle, which proves to be a gland; each of these has a small excretory duct, which passes to the root of the penis, where they unite, and then open by one common orifice into the seminal urethra, one-tenth of an inch after it has entered the penis.

These glands must be considered to correspond with Cowper's glands in the human body, and not as either a substitute for prostate gland or vesiculæ seminales, since they are met with in the female.

In my first account of these parts, from the state of the specimen, I believed these glands to belong to the rectum.

In the female they are smaller than in the male. Their ducts open by one common opening on the posterior surface of the vagina, one-fourth of an inch within the orifice of that canal.

The penis, which is solely appropriated for the passage of the semen, is very short when in a relaxed state, nor is it capable of being much elongated when erection takes place. The prepuce is a fold of the internal membrane of the verge

of the anus as in the bird, and the penis, when retracted, is entirely concealed.*

In laying open the urethra from the bladder the canal led directly into the rectum, and the parts not being in a good state of preservation, I was unable to catch the continuance of the urethra towards the glans; this, however, I made out in another specimen: it takes place about half an inch from the termination in the rectum, is exceedingly small, and near the double glans divides into two, one going to each; and instead of there being a single external orifice as is usual in other animals, one terminates in five small prominent papillæ, the other in four; they take different directions, corresponding to the two openings of the uterus of the female: the urethra swells out into a cavity in the centre of each glans, and thence communicates with all the papillæ, whose orifices are the size of hairs. When water is injected through the urethra, the mode in which it is scattered, by the nine orifices of the papillæ, exactly resembles the pouring water out of a watering pot.

The vasa deferentia open into the membranous part of the urethra before it reaches the penis.

The female organs open into the rectum as in birds: just within the anus there is a valvular projection between the rectum and vagina, which appears to be the proper termination of the rectum.

There is a clitoris with two crura arising from the outer side of the common vestibulum of the rectum, and vagina; it is slender, half an inch long, bifid at the point, and inclosed in a prepuce, the end of the glans only projecting into the

* Plate CXXIX.

vestibulum. The vagina is about one inch and a half long, its internal membrane rugous, the rugæ being in a longitudinal direction; at the end of the vagina is the meatus urinarius, and on its two sides are the openings leading to the uteri. This corresponds as nearly as can be to the kanguroo and the opossum; only in this animal the uterus in the middle line of the vagina is wanting, and on each side, in place of the lateral canals, there are two uteri*, in form approaching to the oviducts of birds.

At the end of each uterus there is a small ovarium covered by a capsule.

When the ovarium was examined by Mr. Bauer, it was found to be filled with yelk-bags, less deeply imbedded in its substance than those of the American opossum, bearing a greater resemblance to the yelk-bags of the fowl; and to make this resemblance more intelligible they were compared together: the great difference between them is, the covering of the ovarium in this animal being strong and opaque, while there is no such outer coat in the fowl, and the clutch of yelk-bags is double in the ornithorhynci, and single in the bird.†

In all the specimens that have come within my own observation, yelk-bags have only been met with in the left ovarium, showing that both ovaria are not generally in use at the same time.

There is an approach to this in the bird, in which there is only one ovarium and one oviduct; but in the chick of the common fowl, before it is hatched, there is a small portion of

* Plate CXXIX. † Plates CXXXIII. CXXXIV.

an incipient oviduct on the right side; but this disappears before the chick is completely formed.

In a specimen I have just received of a female ornithorhyncus paradoxus, where the parts are less corrogated by the spirit than usual, the yelk-bags in the left ovarium are nearly equally separate, and equally varying in size with those in the common fowl, and in the right side no yelk-bags are visible.

In the ornithorhynci there can be no doubt of both ovaria being employed for forming ova; but, from what has been mentioned, it is probable that till one has done produc in ova, the other is not employed. It is curious that there are marsupial bones although there is no marsupium.

As the ornithorhyncus paradoxus resembles the opossum tribe in having a vagina and a penis, these animals copulate exactly like the quadruped, which made it difficult to understand where the ovum was brought to perfection. The uteri appeared not to be convenient situations; and yet, if not there, the position of the meatus urinarius seemed to preclude an ovum from having a shell formed in the vagina or cloacus at the rectum; a necessary protection, before it could be laid externally.

Till I received more satisfactory information, I adopted the former opinion as more consonant to the facts within my own knowledge.

I am now at last relieved from all doubt on this subject, by Mr. Hobbes Scott, secretary to the commission sent out to New South Wales, who returned to England in July, 1821, and has brought me a specimen of the female organs of this animal, taken while sitting upon its nest; and although

no egg was found, the appearance of the parts leave little doubt of the animal having just laid one.

This specimen was intended as a present from Mr. Scott, to Dr. Kidd, professor of anatomy at Oxford; who has very obligingly given it up to me on Mr. Scott's representation, that I expressed more than common anxiety to have an opportunity of examining it. Mr. Scott's account is as follows:—The animal was caught in a lagoon, twelve miles from Bathurst, an establishment one hundred and fifty miles from Sydney, beyond the Blue Mountains, by the son of a Dutch settler: he was shooting in the lagoon, wading up to his knees, and perceived in the still water the point of the beak, and succeeded in seizing the animal: it was found near its nest, which had been formed in the middle of a mound of earth rising above the surface of the water; it formed a cavity large enough for the animal to turn round in. Mr. Scott, four days after, went to the spot; the water in the lagoon was up to his horse's knees. He examined the nest, whose form was entire; but the water (so far had it been broken down) had got into it. The cavity was lined with moss and decayed bark, was of a circular form, raised above the level of the water. No search was made for eggs, which is unfortunate. The natives universally declare that the animal lays two eggs.

The female organs were dissected out by Mr. Hill, surgeon on the establishment, and carefully put in spirit. After tying up the cloacus, believing it contained an egg, which, however, was not the case; but from the globular enlargement of those parts so unlike their natural ordinary appearance, there can be no doubt of an egg having been very recently

laid, the dimensions of which would correspond with the present size of the cavity, which is nearly two inches in diameter, making allowance for the effect of the spirit, which unluckily was so strong, as to corrugate the parts.

The second species of ornithorhynchus we have called hystrix, on account of its spines; however much it differs from the other in its external appearances and habits, it resembles it nearly in the organs of generation.* It is an inhabitant of New South Wales. One of this species was shot in Endeavour Bay, in Van Diemen's Land†: it was seventeen inches long, and, when it walked, the body was two inches from the ground.

The animal which I examined was a male; externally there was no appearance of organs of generation, in this respect being exactly similar to the paradoxus.

Just at the setting on of the heel the hind legs had the same spur already described in the other species; there was also a gland on the posterior part of the thigh, and a duct leading from it to the spur, but smaller than in the paradoxus.

The male organs resemble those of the paradoxus in the form and situation of the testicles, the opening of the vasa deferentia, and the opening of the urinary urethra into the rectum, as well as that of the seminal urethra, which runs in the middle line of the penis.

The penis is very elastic in its substance; when drawn out is about three inches long; in a natural state, before it was hardened in spirit, it of course could be further extended. The glans is divided into four portions of equal length, two

* Plate CXXX.

† Plate CXXXI.

facing to the right, and two to the left; so that there are evidently too adapted to each uterus. All these have an orifice in their centre, surrounded by concentric circles of infinitely small prominent papillæ.*

The female organs I have not seen, but the correspondence there is between those of the male in the two different kinds implies a similarity in those of the female.

The hystrix, in many parts of its form, is a nearer approach to the more perfect quadruped than the paradoxus; and as its tongue is in some respects like those of the manis and myrmecophaga, it was natural to look among the different species of these genera for other points of resemblance.

I have examined a specimen of manis of Sumatra, drawn by the late Mr. Bell, while resident there, whose abilities as an anatomist and draughtsman make his death a considerable loss to science.

The form of the head, the opening of the mouth, and the general appearance of the animal, led me to believe it a still further remove from the ornithorhyncus than the myrmecophaga; and the following circumstances in the internal structure of these two genera confirm this opinion. The myrmecophaga has two cœca, which resemble that of the ornithorhyncus, whereas the manis has no appearance of cœca whatever.

There are two specimens of manis in the Hunterian Collection, which I have examined; one male, the other female. The tongue is small, cylindrical, and very long, and the muscle by which it is retracted lay between the abdominal muscles and peritaneum of the right side, forming a

* Plate CXXXII.

semicircle between the lower end of the sternum and the navel: the theca, in which it was inclosed, had an attachment to the lower end of the sternum.

The tongue was smooth, and there was no appearance of teeth upon it or the palate. There was no cœcum, the intestine suddenly enlarging to form the colon; on each side of the anus there was a bag as in the otter, and most of these animals have no cœcum.

The organs of generation in both sexes were distinct from the anus: the penis was small.

There were two nipples on the breast of the female; the uterus was broad at the fundus; and the two horns separated from each other, nearly at right angles to the middle line of the uterus.

The didactyla is the only species of myrmecophaga which has come under my observation.

The trustees of the British Museum allowed me, in the most liberal manner, to examine both the male and the female.

The tongue had a general resemblance to that of the hystrix; but there were no cuticular teeth upon it, or on the palate; the cœcum was of the same kind, but double, and each of them only one-eighth of an inch in length. In the other parts there was no similarity. The male had four nipples, two on the breast, and two on the belly, corresponding with those of the female.

The organs of generation were not connected with the rectum; the uterus was nearly the shape of the human, its coats very thin, the cavity large, in proportion to those of other quadrupeds: there were no horns; and the Fallopian

tubes went off from the posterior part, which is an approach to the opossum.

By a letter from Cuvier, I find the jubata, the tamandua, and capensis belong decidedly to the class mammalia, and therefore are less nearly allied to the hystrix than I had been led to imagine.

The jubata, which has the organs of generation in both sexes concealed within the verge of the anus, is a nearer approach than any of the other species.

The following characters distinguish the ornithorhynci into a distinct tribe, and make it justifiable to consider them a separate class.

The male having a spur on the hind foot close to the heel, and the female no nipples.

The beak smooth, the body of the animal covered with hair.

The tongue having horny processes or teeth.

The urine passing from the bladder to the rectum without entering the urethra of the penis.

The penis being appropriated to the passage of the semen, which is scattered by a number of orifices over the cavities corresponding to uteri.

Between the ornithorhynchus and birds no link seems to be wanting. The great affinity between their male organs is well illustrated by comparing the penis with that of the drake.*

The mode of generation of the feathered race is so nearly allied to that of the ornithorhynci, that this would be the most proper place for such observations as I have made

* Plate CXXXII.

respecting it; but the hatching of eggs by incubation I mean to take up as a distinct subject, which will be treated of in a future Lecture.

As the ovum in the fowl is impregnated in the oviduct, it is well known that every egg which passes through that canal does not require a fresh supply of semen from the male, what is received at one emission continuing to impregnate several ova in succession. So in some of the insect tribe there is a provision of a still more economical kind. At the lower part of the oviduct there is a reservoir; this is filled with semen, requiring, for that purpose, that the copulation should be of some continuance, and all the eggs as they are laid have the semen applied to them. To prove that the impregnation takes place in this way, Mr. Hunter, in the year 1774, instituted a set of experiments in which I assisted him. He kept a female from the male, and when she began to lay her eggs, he embued the point of a camel-hair pencil with semen from the receptacle of another female in which it had been filled; and as the eggs of the unimpregnated female left the oviduct, he gave them in succession a touch with the brush, and some of them were actually impregnated, and produced young. In many of the attempts the experiment failed, but succeeded in a sufficient number to establish the fact.

The moth of the silk-worm was the insect employed in these experiments.

LECTURE XIII.

On the Ova of Cold Blooded Animals.

THIS subject includes a great variety of animals, which I have divided into different classes.

Those ova which belong to the turtle, lizard, and snake, some of which are viviparous, as several of the lizard tribe, I have had no opportunities of making observations upon; they are, however, to be included in one class with toads and frogs. These last, as their young go through two changes, in the first stage being tadpoles, in the second, frogs, attracted my attention, as being the intermediate link between the lizard and that extraordinary class the syren, that retains the organs fitted to breathe in water, as well as air, through life.

After considering the peculiarities of the ova of the frog, I should have been glad to have followed up the same subject in the syren, but so scarce is the animal, although met with in the caverns in Germany, the lakes in Carolina, and those of Mexico, the females have never been met with in

the breeding season, nor is the form of the male organs yet known.

Next in order to the frogs in their mode of propagating their species, we must consider fishes; more particularly those of the shark tribe, whose copulation is more complete than in the frog, and whose ova in the viviparous kind are inclosed in the same sort of jelly.

All the animals whose mode of generation I have noticed are of distinct sexes, the males having double testicles and double ovaria, the birds excepted.

Below these is a tribe of animals of distinct sexes, which have only one testicle and one ovarium; and as we proceed in this gradation, we have hermaphrodites of three different descriptions.

1. Where each individual may copulate with two other individuals at the same time.

2. Where the double organs are employed by two individuals, reciprocally impregnating one another.

3. Where the individuals impregnate themselves.

After this preface, I shall proceed to explain such peculiarities as I am acquainted with, respecting the ova of these different animals, beginning with those of the frog.

On the Ova of the Frog.

The rana paradoxa of Surinam, in its tadpole state, is larger than in any other species of frog yet known, and so closely resembles fishes, that in that country it is sold as such in the market, for the use of the table, under the name of Jackie; and as the frog produced from it is in the first instance as large as a common frog in this country, it is

highly probable that it grows to a considerable size. Mr. Ireland, a surgeon in the army, who resided several years at Surinam, has brought to England some specimens in different stages of their metamorphosis.

These he has kindly submitted to my examination, and has in the most liberal manner deposited the specimens in the Museum of this College, of which he is a member.

As Mr. Ireland had no opportunity of examining the tadpole, before the hind legs begin to make their appearance through the skin, with a view to render the series complete, I have since examined the progress of the changes up to that period in the ovum of the English frog.

The ova are kept together by jelly of a very particular nature, and as it appears not to have been ascertained where the jelly is formed, I made the following observations upon that subject:—In some frogs that were kept in a damp cellar through the winter, no visible change took place in the ovaria or oviducts, till the tenth of February, although frequently examined, by immersing parts of them in water at different temperatures. At that time a portion of the oviduct, when immersed in water at 80°, swelled out so as to double its size, and when the water was at 120°, expanded very rapidly. On the twenty-fifth of February, the oviducts were seen to enlarge, and on slitting them open, the internal surface was smeared over with a ropy fluid.

A portion of oviduct, two or three inches long, in water heated to 120°, swelled out into a mass of transparent jelly which filled a half pint tumbler, and all traces of the coats of the oviduct were lost.

Upon showing this jelly to the late Sir Joseph Banks, he said that it very much resembled what he had seen when a

boy, in the country during the winter months, upon the ground, and on the boughs of trees, called star-shot jelly, from being supposed to be formed by falling stars; and that it would be worth while to compare them together, and determine whether the common opinion mentioned by Pennant, which Sir Joseph Banks had always believed, was correct. Pennant states that the jelly is brought into this state by the frog having been swallowed by a bird, and the warmth and moisture of the stomach making the jelly in the oviducts expand so much, that the bird is obliged to reject it by vomiting.

Sir Joseph Banks procured some star-shot jelly from Lincolnshire, and Professor Brande found that it was in all its chemical properties the same with that formed in the oviduct of the frog. The ova themselves differ from those of snakes and lacerta in general, in having no yelks. When the tadpole is once formed, it appears to feed upon the jelly, which although not absolutely albumen, is a near approach to it.

In this stage each ovum is pressed into the form of an hexagonal prism, with flattened ends, so as to form the whole into one compact mass.

The tadpole, after it leaves the ovum, has on each side ten filaments projecting from the neck, for the purpose of the aeration of the blood; such filaments must be considered as temporary gills.

The lacerta of this country, called the newt, or eft, in its larva state, has the same projecting filaments, which drop off when the lungs are formed: they are more complex in their structure, and only three in number on each side.

This circumstance shows, that the larva of an eft is a species of tadpole, and that the eft itself does not belong to the tribe of lizards, but is a nearer approach to that of frogs.

In the tadpole, as soon as the abdomen begins to enlarge, these external filaments disappear.

Twenty-four similar filaments are met with in the fœtus of the shark while contained in the egg, which drop off before the fœtus escapes from the shell.

The spawn of an English frog was collected on the first of April, 1816. On the fifteenth, the tadpole left the egg, but the filaments or external gills were not visible, only a deep notch on each side, nearly separating the head from the body. On the twenty-third, the ten filaments on each side were distinct. On the twenty-seventh, they disappeared. In June, the external orifice on the left side for the water to pass off from the gills was formed, but none was seen on the right. On July the eighth, the hind legs began to appear, but the toes were not separated. On the fourteenth of July, the hind legs were seen externally completely formed, and on opening the skin of the chest, the fore-legs were equally so; but there was no external projection by which this could be known. The lungs were completely formed.

On removing the intestine, there was no fat deposited on the loins.

On the sixteenth, the contents of the intestine were voided in considerable quantity.

On the eighteenth, the elbows of the fore-legs projected under the external skin, and so much of the contents of the intestine had been voided as to give a taper form to the lower part of the body.

On the nineteenth, the fore-legs were completely disengaged, and appeared externally; the mouth had become wide, like that of a frog.

The tail had a notch at that part where it afterwards separates; the intestine was reduced in diameter, and to the length of that of a frog; an appearance of oil was seen on the loins.

On the twenty-third, the tail had dropped off, leaving the projecting root. The animal had left the water and remained among the grass.

Behind the intestines upon the loins were several small membranous appendages in an empty state.

On the twenty-eighth, the root of the tail had wholly disappeared; the appendages had become more opaque.

The ova of the frog appear to be hatched at very different periods, since some of the tadpoles become complete frogs, before others have their hind legs protruded through the skin.

Upon examining the tadpole of the rana paradoxa, just when the hind feet appear externally, I found the mouth very small, and nearly round, the teeth cuticular, the upper ones overlapping the under; the œsophagus, stomach, and intestine, forming one uniformly continued canal, which passed down to the lower part of the abdomen; it was bent upon itself, passed up again, and then made a great number of coils in a circular form; its coats were very firm, its capacity very small. There were three gills completely enclosed on each side; and on the left, a small round orifice for the water by which the gills are supplied to pass out, but none on the right.

When the tadpole has arrived at its full growth, and the hind legs completely formed, which takes place, according to Mr. Ireland's observations, in fourteen days after their first appearance, the cavity of the abdomen has become exceedingly enlarged, the intestine very capacious, its coats almost as thin as a cobweb; it was completely distended, through its whole extent, with a soft substance, which when burnt had the smell of hay.

Behind the intestine, all along the posterior part of the abdomen, a large quantity of fat was met with, of a yellow colour, enclosed in long, thin, transparent membranous bags; no part of this fat was met with in the prior stages of the tadpole's growth. The lungs were completely formed.

When the mouth of the tadpole changed into that of a frog, and the fore-legs were completely protruded, the tail remaining entire, which happens twenty-one days after the last-mentioned change, the large coils of intestine were found contracted into a canal, one-fourth of its original length; the coats had become as firm as those of an artery, the external surface was corrugated, and the canal empty. The stomach had become a distinct cavity, and there was a contraction, where it terminated in the intestine.

All these parts were imbedded in fat, which filled the whole of the abdomen not occupied by the liver, which had acquired a large size.

The lungs were filled with air, and the gills had entirely disappeared.

When the tail had dropped off, leaving the projecting root, which takes place in seven days more, the only internal

change afterwards met with, was that no fat whatever was found in the cavity of the abdomen.

The great length of the intestine which has been described has nothing analogous to it in the caterpillar, and is probably confined to the frog tribe.

The egg of a frog bears no proportion in size to those of other animals of the same class, and differs from them in having no yelk; therefore, although it contains sufficient materials for the formation of the tadpole, something is still wanting, before it can be metamorphosed into a frog; and in the tadpole state, a store of fat is laid up, beyond what is required for its own immediate support and future growth, to furnish the necessary means of supplying the different structures belonging to the frog, not already existing in the tadpole; and this fat appears to be formed in the intestine.

The length of the intestine in the tadpole, when its relative proportion to the size of the animal is considered, exceeds what is met with in other animals.

In the tadpole of the Surinam frog, the intestine, after it has acquired its full size, does not remain of this enormous length beyond the period of its metamorphosis into the frog taking place; and what is deserving of particular attention, the fat is deposited as soon as the intestine has acquired its greatest extent, and no sooner is the intestine reduced in length, than not only no more fat is deposited, but all that was previously formed is found to have been consumed in producing the metamorphosis into the frog; which leads me to conclude, that such a deposit of fat is necessary to this metamorphosis, and that such unusual length of intestine is required to admit of so large a quantity of fat being produced

in so short a time; and, therefore, that the intestine is the laboratory in which the fat is formed.

To ascertain whether the necessity of such a supply of fat is occasioned by the soft parts of the tadpole not being convertible into bones, and other parts of the frog which did not exist in the tadpole, or simply from a deficiency of materials, I have had the assistance of my friend and fellow-labourer in Animal Chemistry, Mr. Hatchett, who some years ago ascertained, that the yelk of an egg is essentially composed of concrete oil, combined with a small proportion of albumen; and he has made out the following important facts:—

That the spawn of the frog has no yelk, and contains no oil whatever; he also corroborates Professor Brande's statement, that it consists of a substance intermediate between albumen and gelatine, inclining principally to the former.

That the ova of the land snail, both those that have a shell and those that have only a strong membranous covering, have no yelks, and consist of albumen; since these substances coagulate in proof spirit of wine, and, when so coagulated, and examined sometime afterwards, appear not to contain any oil. That the ova of the lobster have no yelk, and contain no oil.

The following observations of Mr. Hatchett, upon the colouring matter of the spawn of the lobster, are sufficiently interesting, not to be passed over in this place:—

The spawn of the lobster, when recent, is filled with albumen, mingled with a substance of a dark olive colour; and whilst the former, as usual, is coagulated by heat, the latter becomes of a vivid red. This, Mr. Hatchett observes, is

the colouring matter of the shell, which, three or four years ago, Professor Brande found to become red by the application of acids, without heat: for dilute sulphuric, nitric, muriatic, and the strong acetic acids, immediately produce the same effect on the colouring matter of the spawn; but this is not the case when a weak acid, such as common distilled vinegar, is employed.

When this bright red colour has been produced by the above acids, it appears to be permanent, excepting when nitric acid has been used; for then the red colour changes to yellow, which, by the effusion of ammonia, becomes orange colour, as is usual with animal substances so treated.

Dilute nitric acid in which it had been digested afforded slight traces of a phosphate, which was not phosphate of lime.

As the red colour is produced by acids as well as by heat, there was some reason to expect that it would have been diminished by a great excess of the alkalies: but not the smallest effect was produced by any of them; and, indeed, so far from it, that the recent spawn, when put into a solution of caustic potash, became in a few seconds changed to as bright a red as when the mineral acids had been employed.

The red colour is also produced by the effects of air, light, and the incorporation of moisture; for paper or linen, which has been stained with the olive coloured substance, becomes red in the course of a few minutes; so that in this respect it somewhat resembles the secretion obtained from the purple whelk.

The purple colour of this last does not, however, suffer any change, whilst the colouring matter of the lobster in the

course of some days becomes of an ochraceous colour. In this state it seems to be permanent; for it was retained by linen which had been marked with it, after repeated boiling in water, and washing with soap.

From these cursorary experiments, Mr. Hatchett observes, that this animal colouring substance is apparently of a peculiar nature, and that it is the same in the common cray-fish and the crab; but in the two last, it has already assumed its red colour.

That the ova of the salmon and pike have no yelk, and consist principally of albumen, as they coagulate by heat; but contain also a small portion of oil, which perhaps is a substitute for yelk.

That the ova of cartilaginous fishes, as well as those of the lizard and snakes, have regularly formed yelks, like that of the hen, composed of the same ingredients: but in both the viviparous and oviparous sharks, there is no perfectly formed albumen; but in its place a gelatinous substance, which Professor Brande ascertained to be intermediate between gelatine and albumen, similar to what is met with in the spawn of the frog.

In addition to that which has been above stated, Mr. Hatchett has communicated to me the following observations:—

The yelk of the eggs of birds is principally and essentially composed of a butyraceous oil, combined with a small proportion of albumen, the average of which, in the yelk of the common fowl, amounts to about one-fifth part; the yelk, when triturated and diluted with water, forms (as is well known) an emulsion in a high state of concentration.

In milk, the caseous part, or curd, corresponds to the albuminous part of yelk, as the butter in milk does to the other part or oil of the yelk. The principal difference, therefore, between milk and yelk is, that the former is in a dilute, and the latter in a concentrated state. Hence (Mr. Hatchett observes) it appears, that many of the oviparous animals, during the period of incubation, are nourished by a pabulum similar in quality to that by which young viviparous animals are supported; whilst the great degree of concentration of this pabulum, in the first case, is essentially necessary, in order that the quantity of nutritious matter which is required during incubation, and which is included within the egg, should be condensed into the smallest possible bulk.

Young viviparous animals are at first incapable of supporting themselves by those substances which are afterwards to become their food, and they are therefore nourished for a certain period of time by the milk of their mothers; but young oviparous animals, such as the chicken, partridge, and birds in general, come forth from their shell complete in their bodily faculties, and immediately partake of the food to which the parent birds are accustomed: so that it seems they are prepared for this, and are nourished during incubation by a substance similar in its nature to that by which young viviparous animals are supported, or suckled, during a certain time after their birth; and that the process corresponding to that of suckling, is, with regard to birds, performed and completed in the course of incubation.

The experiments which Mr. Hatchett has made upon the ova of these different tribes of animals, lead to the conclusion that in all ova, the embryos of which have bones, there is a

certain portion of oil; and in those ova, whose embryos consist entirely of soft parts, there is none.

This conclusion is much strengthened by the peculiarity, which it has been my object to point out, of the tadpole laying up a magazine of fat before the metamorphosis into a frog takes place; it is, therefore, rendered probable, that a certain portion of oil is necessary for the formation of bone, and that the proportion in different ova corresponds with the greater or less degree of hardness of the bones of the embryo.

As there is a jelly surrounding the ova of the ovi-viviparous dog-fish, similar in its chemical properties to that which forms the spawn in the frog, it will be better that I give an account of the mode of breeding in that fish, before I state Professor Brande's chemical analysis, which is applicable to both.

On the Mode of Breeding of the Shark.

That some of the shark tribe do not lay their eggs, but hatch them within the body, and that others lay them in the same manner as the skate, has long been known; but nothing seems to have been accurately made out upon either of these subjects, I am, therefore, induced to bring forward the following observations respecting them:—

In my examination of the squalus maximus, I found that it closely resembled in its internal structure, the squalus acanthias of Linnæus, a fish common on the Sussex coast, which gave me an opportunity of paying particular attention to the anatomy of all the parts of this species of dog-fish.

In December, which is the breeding season of this particular species of dog-fish, I procured specimens of the male and female, in all the different stages of impregnation; from the dissection of these is drawn up the following account of the organs of generation:—

The male organs were found in two very different states; in one, the testicles were small, and the penis scarcely discernible; in the other, the testicles were larger, the epididymus and vas deferens turgid with semen*, and the penis had put on the appearance of a projecting infundibular canal, capable of conveying the semen into the oviduct of the female, resembling in its form the penis of the squalus maximus, only upon an infinitely smaller scale.

The pendulous bodies close to the anal fins of the male, which have been mistaken for penises by many physiologists, and by others more rightly considered as claspers to lay hold of the female, bear a close resemblance in their form to those of the squalus maximus; and, from every part of their mechanism, there can be no doubt that they perform that office.

In the breeding season, they become more fleshy than at other times, the muscles at that time being enlarged.†

The insertion of the penis into the female is not unlike that of the common fowl; but the penis is fitted to inject the semen further into the oviduct than can be done by the grooved penis of the cock.

When the holders embrace the female, they are spread out; even after the fishes are dead, the penis is brought forward by that means, so as readily to enter the external orifice of

* Plate CXXXVII. † Plate CXXXVIII.

the oviducts, to which it is guided by the prominence of the clitoris.

The mode in which the semen enters the penis is so unlike what is met with in other animals, that it deserves to be particularly explained.

The vasa deferentia are convoluted in their course, but become straight, and much enlarged at the lower part; and instead of going on to the penis, terminate by two wide orifices on the posterior surface of what may be called the urinary bladder, which is of an oval shape, and partially divided into two by a septum, on each side of which the ureters enter it. From this cavity the penis is continued like the neck of a Florence flask, and the semen, before it can arrive at the penis, fills the bladder, and is propelled by the action of the muscular coats of that viscus, by which the semen acquires velocity, and the penis is rendered turgid during the whole time that such force is applied to the liquid passing through it.

This bladder at other times is a reservoir for the urine, which must be considered a secondary office in a fish constantly living in water.

The female organs, before they undergo the necessary changes to form the eggs, and prepare them to receive the influence of the male, are very little developed: the ovaria are not larger than the testicles of the male before the breeding season, and resemble them both in their appearance and situation: the oviducts are so small, as with great difficulty to be traced; and the clitoris is just large enough to be distinguished. When the eggs are formed, all these parts develope themselves.

The ovaria become exceedingly vascular, and the yelks become conspicuous. They are met with in all the stages of their increase, from the size of a pea to that of a walnut; at which size they pass into the oviduct.

The number of yelks which are ready at any one time to pass into the oviduct varies exceedingly in different fishes, and even in the two ovaria of the same fish.

I have seen five of the full size in one ovarium, and only two in the other; in another fish there were three in each, and so on to a great variety.*

The oviducts enlarge, and become exceedingly extended. In a fish twenty-seven inches long, each oviduct was twenty-six inches in length; its internal surface was formed into three distinct cavities, separated from one another by contractions in the coats of the canal.

The first of these begins from the orifice that receives the yelk, and is pyramidal in its form: it is ten inches in length, and gradually diminishes in its capacity, the coats being extremely elastic, which throws the internal membrane into folds in a longitudinal direction, taking a very serpentine course. At the termination of this portion, the contraction is formed by the interposition of a substance of a fibrous structure, and of a light grey colour, between the external coat and internal membrane, forming a circular band, which is divided into three equal parts by two circular parallel lines on the internal membrane. This band is half an inch broad, and its internal surface has a glandular appearance.

* Plates CXXXIX. CXL.

The second cavity is only six inches long, its internal membrane is very vascular, and thrown into plicæ in a longitudinal direction, longer, thicker, and less numerous than those of the first portion: they are smeared over with mucus. This cavity is separated from the third, by a transverse fold of the internal membrane in a contracted state.

The third portion is ten inches long, and in this cavity the eggs are retained, till the young fishes are formed, and capable of taking care of themselves. The eggs, however, are not loose in the oviduct, as in birds; but a certain number of yelks, that are in a state to leave the ovarium at the same time, are inclosed in a membranous bag, piled one upon another. This bag, at its upper end, is grasped by the contraction which separates the middle and lower portion of the oviducts; the other extremity, which is in the form of a blunted cone, is loose and moveable in the surrounding cavity. The eggs are enveloped in a transparent jelly, which occupies every part of the bag, beyond that in which the eggs are contained.

The clitoris becomes so much enlarged as to project externally; its base swells out in the form of a heart, as it is painted upon cards, only that it is much more pointed; the posterior surface adheres closely to the parts behind it for one-half of its length, the other half is loose; and on its upper surface there is a groove, passing on each side towards the orifices of the two oviducts. The nymphæ are formed by a fold of the termination of the rectum, and project laterally; they are very vascular, and compose the external orifice of the vestibulum, beyond which are the contracted openings of the oviducts. After impregnation has taken

place, the pendulous portion of the clitoris becomes flaccid and narrow.

When the young dog-fish is completely formed, the yelk remains attached to the belly by a long cord, consisting of blood-vessels, and the fish swims about; but if the vessels going to the yelk are wounded, the fish immediately dies.

What number of the shark tribe have this particular mode of hatching their eggs is not at present known; but there is reason to believe, that it is very general, since the eggs, or their shells, belonging to the other tribe, are rarely met with, which would not be the case if many were oviparous.

The squalus maximus, I have no doubt, is of this kind; and from the following memorandum of my late friend, Dr. Patrick Russel, given to me by the late Sir Joseph Banks, the large shark met with between the tropics breeds in the same way:

"A shark, caught on the fourteenth of November, 1781, in lat. 7° N., measured eight feet seven inches, the tail included. The head and body of a dark blueish colour, the breast and belly of a silver white. Upon opening the belly, the two oviducts were distended with young ones, contained within an inner cavity, swimming in a white gelatinous liquid, thicker than the liquor amnii of quadrupeds.

"The right oviduct contained twenty-one young ones, the left twenty; of these, twenty-five were males, and sixteen females: they were all nearly of the same length, between nine and ten inches, and each of them had the yelk attached to its belly by a cord of considerable length.

"In the lat. 5° N. another female shark was caught, seven feet long; it had only eight young ones, four on each side."

Of the oviparous shark I could obtain no information, but what is contained in Bohadsch; in whose works there is an engraving of the egg, and of the shark to which it belonged, caught in the Mediterranean.

So little has this subject been attended to by naturalists, that no mention is made that I know of, in any author, of such eggs being met with upon the coast of Great Britain; I was, however, so fortunate as to find a shark's egg on the sea-beach at Worthing, in Sussex, in September, 1809; and in the course of that month procured several of them, containing young sharks in all the different stages of their growth. Their eggs are exactly similar to the engravings in Bohadsch: when minutely examined, there is on each side of the egg a small slit, for the admission of salt-water within the shell.

In the latter end of October, 1809, a young dog-fish was sent me, thirteen inches long, which exactly resembled the embryo in the egg, and proves to be the squalus canicula of Linnæus; it had been feeding on the worms met with in the sand-banks, some of which were found in its stomach.

The ovi-viparous and oviparous dog-fish differ materially in the form of the stomach.

In the first, the pyloric portion is short and wide; in the other, long and narrow, like an intestine.

As there are larger sharks, with both these kinds of stomach, it is reasonable to believe they have also the same differences in their mode of breeding.

The jelly that forms the medium in the frog and the shark, on being examined by Professor Brande, was found not to

mix with water; but, at common temperature, expands slowly in that fluid to about twelve times its original bulk.

At a temperature of 100°, this expansion is much more considerable, and the substance puts on the appearance of an attenuated and nearly transparent jelly; but none of it is dissolved.

The expansion seemed to depend on the absorption of water by the gelatinous substance, the proportion of water taken up being very great. A piece of unexpanded substance, of the size of a large pea, requires rather less than three ounces of water for its complete expansion; and a mass of jelly, equal in bulk to three ounces, is formed.

The substance, dried at a temperature of 212°, becomes brittle; but when it is put in this state into moderately warm water, it again expands, becoming nearly as bulky as before.

Digested in alcohol, it becomes brittle and opaque, and contracts to about one-half of its original bulk. If in this contracted and perfectly brittle state, it be put into warm water, it again expands as before. But when once expanded, it is neither hardened nor coagulated by alcohol.

It is soluble in nitric, sulphuric, and muriatic acids. Nitric acid, diluted with its weight of water, when poured upon the substance recently removed from the oviduct, changes its colour to a deep yellow, and rapidly dissolves it on the application of a moderate heat. This solution is of a yellow colour. The caustic fixed alkalies render it slightly turbid, when not added in excess; in this case the mixture becomes perfectly transparent.

Muriatic acid, at a boiling temperature, dissolves the

recent substance very rapidly, forming a solution of a deep blue colour.*

Concentrated sulphuric acid dissolves the substance from the oviduct slowly, and forms a brown solution.

If heat is applied, the colour approaches to black.

No change is produced by the alkalies on these sulphuric solutions.

The substance is very rapidly dissolved by a boiling solution of caustic potash. The compound is imperfectly saponaceous, its transparancy is not disturbed by the addition of sulphuric or muriatic acid; but nitric acid, added in a small excess, renders it slightly turbid.

None of the solutions which have been described afford any precipitation on the addition of tannin; neither does water, in which the substance has been boiled, yield even the smallest trace of gelatine.

No coagulation is produced in this substance by voltaic electricity, from thirty double plates of four inches.

These experiments show, that this substance, found in the oviduct of the frog and that of the ovi-viviparous squali, is of a peculiar nature; its characteristic property being the remarkable power of expansion by the absorption of water.

It is distinguished from gelatine by its insolubility in water, and by affording no precipitate with solutions containing tannin; from albumen, by not coagulating on the

* The deep blue colour of this solution is instantly destroyed by the addition of an alkali: it seems to arise from the formation of a very minute portion of prussiate of iron. Mr. Hatchett has observed, that some of the varieties of albumen afford a blue solution, when long digested in muriatic acid; this is probably from the same cause.

application of acid or electricity; and by forming compounds with the alkalies which are not saponaceous.

In some of its other properties it would appear, as far as regards its chemical habitudes, to be a substance intermediate between albumen and gelatine.

The properties of this jelly, which seem to answer two purposes very different in themselves, (one affording a nutriment for the embryo during its developement, the other a medium through which the blood of the embryo is aerated,) led me to take a view of the various modes by which the fœtal blood is aerated in the different classes of animals.

The provisions of nature for this very important purpose form a beautiful series.

The ova of many fishes, as the salmon and trout, are laid in the sand and gravel; and the fœtal blood of the embryo is aerated by means of the surrounding water. These fishes, therefore, are found to spawn as near as possible to the sources of springs, where the water coming from the earth is in a state of high aeration. The ova of others, which spawn in waters less impregnated with air, are deposited on the leaves of water plants and weeds that give out oxygen; by means of which the embryo has its blood aerated. The tench and the pike are of this kind.

The ova of the perch are surrounded by a jelly, as in the frog; and the water it imbibes probably aerates the fœtal blood.

These observations were suggested to me by my friend, Sir Humphry Davy, who has made it a part of his amusements to attend to the habits of fishes. The ova of the oviparous shark, skate, and all that tribe, although too strong

in their coats to be penetrated by the sea-water, have natural apertures for its admission and escape, these being two on each side of the egg, so that there is a current of sea-water constantly supplying the egg with air.

In the ovi-viviparous shark, the ova being surrounded by the same jelly, the sea-water is applied to the membrane in which they are inclosed, the opening of the oviduct admitting it for that purpose.

In the bird, the eggs being surrounded by atmospherical air are supplied with it through the pores of the shell, which readily transmit it to the membranes of the embryo.

In all these tribes, the mode in which the air is applied to the fœtal blood is as follows:—

Besides the common circulation of the blood from the heart of the embryo, to the different parts of its frame, there is a lesser circulation from the arteries to the membranes, which inclose the embryo, and which are in contact with the aërated water, or air, in which the egg is deposited; in this circulation, the blood receives the influence of the air through the membrane, and conveys it into the system. In birds, the young are fed and taken care of by the parents, after the eggs are hatched, and in them this fœtal circulation is immediately stopped, on the embryo breaking the shell, and the remaining yelk and albumen is drawn up into the belly as a supply of nourishment, till the stomach has acquired the power of digestion.

In the ovi-viviparous shark, the young ones swim about in the surrounding jelly with the yelk attached to the belly by a long vascular cord, till fitted to swim in the sea, and all this time the blood is aërated from these membranes.

After the young leaves the bag in which the eggs are contained, the yelk is taken into the belly as in the bird.

From these facts it appears that oxygen is necessarily an ingredient in the blood of all living animals.

The animals next in order to fishes, and which I shall consider as belonging to a distinct class from the great peculiarity of the male having only one testicle, and the female one ovarium.

The existence of such animals more than any circumstance whatever comes in proof of the whole scheme of animal creation, being composed of an undivided chain of gradation of structures. There is no other ground that human sagacity can discover for such a deviation from the common established principles of structure, in animals of separate sexes being made.

This is the structure of the sepia, the animal at the head of this tribe, which from its peculiarities cannot be brought in without violence into any regular arrangement of animals according to the gradation of organs, but is admirably suited to be at the head of a distinct class in respect to its organs of generation.

One of the genera of this tribe, like the soldier-crab, being in the habit of taking possession of such shells as can give it a convenient habitation, without interfering with its mode of progressive motion through the water, has led the principal comparative anatomists on the Continent into the belief that, instead of its being a parasitical animal, it is really the natural proprietor of the shell in which it is found, and therefore have classed it among animals with external shells; and as the shell of the argonauta is that in which the

animal is most commonly met with, (for if it is proved to be parasitical, it may be found in others,) they have made it out to be the argonaut itself. The fallacy of this opinion we are enabled to prove in two different ways.

One of these is its having no connection with the shell; the other, the formation of the eggs.

Mr. John Cranch, zoologist to the unfortunate expedition to the Congo, in the Gulf of Guinea, and afterwards on the voyage, took several of the sepia octopodia of Linné in the shell of the argonauta. On these he made the following observations:—he placed two of them in water while yet alive: they very soon protruded their tentacula, and swam about below the surface of the water, having all the motions common to the polipus of our seas. By means of their cotyledons, they firmly adhered to any substance with which they came in contact: while they were sticking to the sides of the basin, the shell might easily be withdrawn. They had both the power of withdrawing themselves within the shell and of leaving it altogether: one individual quitted its shell, and lived several hours swimming about, showing no inclination to return to it; and others left the shells, as he was taking them up in the net: They changed colour as the octopodia do: when at rest, the colour was pale flesh colour more or less speckled with purple, the under parts of the tentacula bluish grey, the suckers whitish.

One male only was sent home, all the others were females, who had deposited their eggs on the spiral part of the shell, or what is more probable, the eggs rested there, not being able to disengage themselves, so as to fall into the sea as they do when they are laid by the female under common circum-

stances.* These eggs, as will be seen in the drawings, are exactly the same as in the common sepia octopodia.

It has been asserted, that in one of the eggs of this species of sepia the young shell of the argonauta has been seen through the membrane; this, however, must have been a deception, and most probably the dark colour of the yelk, which is very large, has led to the mistake.

In the first volume of these Lectures, I have given my reasons for believing the shell of the argonauta to be itself an internal shell; and it is probable, that no opportunity may ever occur of determining that point, as the shell has never been brought under our observation till after the animal's death; but we have abundant proof from the eggs of the voluta pyrum and helix janthena †, that the shell is not formed till the embryo is ready to leave the egg: and both these animals come under the same head as the sepia, only having an external shell, which requires a peculiar management of the eggs till they are hatched. In the octopodia, the mode by which the eggs are connected together is seen in the plate. In the officinalis the eggs are attached by fibres going off from the middle stem; after running for some way parallel to it, then becoming loose; and wherever these filaments cross one another, they adhere at that part which produces complete entanglement, so that instead of the bunches resembling dried grapes, which those of the octopodia very much do, they form clusters; and the mode by which the separate eggs are attached to the stem requires a particular examination to determine; and the pedicles are too short to admit of this being easily done. In the loligo, every egg has its pedicle

* Plate CXLII. † Plate CXLI.

strung upon the stem by a ring fitted to it; but in the voluta pyrum or chank, the shell of which is used in the East Indies for beating the cloth by the men who wash linen, and met with along the coast in great numbers, the ova are very differently connected together. A friend of mine saw the female shed her eggs; a mass, apparently of mucus, passed along the deep groove in the lip of the shell in the form of a rope, several inches in length, and sunk to the bottom: this rope of eggs, inclosed in mucus at the end last disengaged, was of so adhesive a nature, that it became attached to the rock, or stone, on which the animal deposited it. As soon as the mucus came in contact with salt water, it coagulated into a firm membranous structure, so that the eggs became inclosed in membranous chambers, and this connected nidus, having one end fixed and the other loose, was moved by the waves, and the young in the eggs had their blood aërated through the membrane, and when hatched they remained defended from the violence of the sea till their shells had not only been formed but had acquired strength.

I was exceedingly desirous of getting possession of a specimen of this camerated mucous structure, in which the univalves are deposited during the period of the embryo's formation, and at last procured one from my friend, Mr. Lee, of Hammersmith*: it came from South Carolina, and the small shells bore a near resemblance to those of the voluta.

In looking at the voluta pyrum shells in different collections, to see if there are any marked distinctions between

* Plate CXLI. fig. 7.

those of the male animal and the female; and conversing with my friend, Sir Alexander Johnstone, late Chief-justice at Ceylon, he told me that he had several of these shells in his possession, some of which had the spiral turns open, and the others close, so as to be nearly on the same plane. Conchologists, from the belief that all the animals in these shells are hermaphrodite, have considered them two distinct species; but on comparing the shells, I am induced to believe, the close spiral is that of the female; the body of the shell is more tumid, and the passage for the ova is more uniform and wider than in the other; and from Sir Alexander Johnstone's account they are met with in the same situation.

In the shell of the helix janthina, which we know from the ova deposited on it to be that of a female, the body of the shell has a bold swell, probably greater than in the male, which may hereafter become a mark of distinction. In this animal each ovum has a separate cell; in the volutes, there are several in one.

Having taken notice of the ova of different kinds of animals with internal and external shells, the animals of which are of different sexes, I shall add another genus from the vermes intestinales, which come under the same description, although till now I was not satisfied upon this subject. Werner published a plate of what he called the male of the lumbricus intestinalis, which has been copied by later anatomists, but there was not sufficient internal evidence of the difference between it and the specimens of the females; added to this the proportion of males being so small, that, in the examination of hundreds, none were met with, yet

Bremser has shown, and from his reputation and experience in these worms, I am ready of belief to what he states on this subject, because he gives a decided character, which pervades all the males, of four distinct genera; this is a spiral turn at the tail, and the aperture at which the penis passes out is where this spiral begins, whereas the body of the female, as is well known, is straight; and in Werner's figure of a supposed male, he makes it straight, so that there is no distinguishing character to support his assertion. Bremser calls our lumbricus intestinalis, ascaris lumbricoidis, and the other three, that he asserts to be of distinct sexes, trichscephalus impar, oxyurus vermicularis, bothriocephalus.

On the Ova of Hermaphrodite Animals admitting of double Copulation.

Having stated all that has come under my observation respecting the mode of generation of those animals of distinct sexes, with only one testicle, or at least in which there are not two regularly formed testicles, I shall now proceed to the next class in the regular order of their gradation.

The garden snail and the lumbricus terrestris, which are not only hermaphrodite but have double copulation, so that they mutually impregnate each other, belong to this class.

There is indeed a curious intervening link in particular genera of the helix tribe, mentioned by Adinson, which I cannot pass over, since a man of his zeal and labour entitle him to my belief. He describes two genera, in which, although each individual is a complete hermaphrodite, yet, from the situation of the organs, mutual impregnation is

inadmissible. He calls one, genus bulinus, the other, coretus; in the shells of both genera, the spiral turns of the shell are from left to right, and the lateral openings leading to the organs of generation are on the left side; but in other genera the turns of the spiral shell are in the opposite direction, and in them the apertures of the organs of generation are on the right side: this is the case in some of the fresh water snails in the little river of the Gobilins, near Paris, called buccinum subflavum pellucidum 6 orbium (Lister), and another 4 orbium.

The ova of the bulinus and coretus are thrown out covered with jelly as in the spawn of the frog.

The copulation in these snails is prevented from being mutual, from one of the apertures of the organs of generation being at the root of the horn, the other lower down, but on the same side, so that each individual can have connection with a male and female at the same time, and in this way the number of animals so copulating may form a chain or chapelet.

After having noticed this extraordinary mode of copulation, which does not appear to have been quoted by any of our modern comparative anatomists, I shall proceed to give such observations respecting the garden snail as have come within my own knowledge.

The following observations on the garden snail were made in the year 1773, the first year of my being initiated under Mr. Hunter in Comparative Anatomy.

He kept snails to ascertain their mode of breeding, and the notes that were made at the time in my own handwriting I now copy.

August 5th, 1773, a snail laid its eggs and covered them over with earth. Mr. Hunter took one out and examined it; the egg was round, its covering strong, and of a white colour, with a degree of transparency; it had no yelk; a small speck was observable, with a magnifying glass, in the transparent contents.

On the ninth, no apparent change had taken place.

On the eleventh, the speck had enlarged, but was become too transparent to admit of its circumference being distinguished.

On the twelfth, the embryo was indistinctly seen.

On the fifteenth, the embryo filled one-fourth part of the egg, but the other parts were still indistinct.

On the eighteenth, the body of the embryo had become larger, and the covering thicker.

On the nineteenth, the coverings or shells of all the eggs were more or less dissolved, so much so that Mr. Hunter thought all the eggs were rotting, and the whole brood of young would be lost.

On the twentieth, the young snails were hatched, and the shells completely formed.

These eggs being supplied with no defence, proves that the camerated cases are only necessary for animals whose shells are found in water.

The lumbricus terrestris has double organs of generation, and double copulation, as well as the snail; but in what manner that takes place, and what processes are gone through before the young are produced, has not been clearly explained, whatever attempts have been made for that purpose.

It is now six years since I engaged with Mr. Bauer in this enquiry: our labours, it is true, have been very frequently interrupted by some more interesting subjects; one of these, the mode of carrying on progressive motion against gravity, afforded us a hint respecting the copulation of some insects, the female being secured during that act by cups on the thigh of the male producing a vacuum, which is met with in the dytiscus, that copulates under water. The winter seasons gave us temporary checks, by inducing the animals to penetrate into the earth beyond our reach. The same thing happened one very dry summer; and Sir Joseph Banks, who took a considerable interest in the enquiry, it being the first in which Mr. Bauer had given me his assistance, dug a pit at Spring Grove, to enable us to come at the retreat of the worms: we found them collected three feet below the surface, where they found sufficient moisture.

We have now completed this investigation; and the annexed drawings represent the different parts so well, that little farther information is required than an explanation of the plates themselves.

The mode of copulation resembles the leech more than the snail; but when the animals are separated, there is this curious difference:—In the leech, an animal much smaller than the earth-worm, there is a penis protruded an inch in length, and about a quarter of an inch lower down upon the belly is the orifice leading into the uterus; so that the first impression I received was, that this long penis enabled the animal to impregnate itself, nor was this notion removed till my friend, Dr. Johnston, gave an account of their copulation.

When the two worms are separated, no appearance remains upon the surfaces of the belly, that were in contact, of either penis or opening into the ovaria or uterus. There is a pair of longitudinal suckers on each side near the head, and a little lower down on the same line a pair of hooks corresponding to each of the suckers. While the worms are in copulation, the lips of the suckers swell out exceedingly, and form a cavity, which is filled with mucus. During copulation, the heads of the worms are placed in opposite directions, and the suckers of one worm are fixed to the hooks of the other: the copulation is continued a considerable time: Mr. Bauer has known it an hour and a half before they separated.

Two worms come out of two neighbouring holes at the distance of a few inches, so as to be able to copulate, while about one-third of each worm remains in the hole: this enables them to keep their hold of the ground, and to pull themselves asunder and retreat whenever they are disturbed.

Although there is no passage that can be traced from the testicles or the ovaria, which are in themselves very conspicuous to the external surface, there can be no doubt, by the great change the external lips and hooks undergo, that the semen is forced by suction from the testicles, and conveyed to the ovaria, from which the impregnated eggs are carried along to lateral cells placed in two rows, one on each side of the animal, and there deposited. In this respect it is similar to the leech, the impregnated eggs being found in uteri similarly placed; the force of suction in the worm performing what a penis, nearly one-fourth part the length of the animal, does in the leech.

It is in these lateral uteri or nests that the ova are hatched in the form of a species of grub: in this state nourishment is conveyed to them from a corrugated canal, situated in the cavity of the intestine, but having no communication with it; but there are openings leading into all the nests on both sides. It is in this situation the small grubs go into a crysalis state. The outer cuticular covering has an oblong form, sharp at the two ends. These crysales have their ends forced out at the lateral pores of the animal, and the worms eat their way out and disengage themselves.

In this stage the cuticular coverings of the crysales have been mistaken for projections used by the worm in its progressive motion.

In the leech, the eggs are hatched in these lateral cells, and then squeezed out at the external apertures, forming a slimy rope, in which the animal is inclosed; but it first disengages its head by its teeth, and then by wriggling itself gets the whole body released, leaving the slimy mass coiled up in an oval form exactly resembling a cockoon with a longitudinal perforation through it: this mass the leech deposits upon the surface of the water, and the young leeches, when sufficiently formed, eat their way out.

Although the object of the present investigation was the mode of generation of the earth-worm, no part of the animal's structure represented by Mr. Bauer's pencil, more especially in magnified drawings, can fail to be elucidated; and in this case my former observations on the circulation of the blood will receive a great and valuable advantage.*

* Plates CXLIII. CXLIV. CXLV. CXLVI. CXLVII. CXLVIII.

On the Ova of Self-impregnating Animals.

Those animals that have double organs of generation, in which every individual is capable of adding to the stock, make a very curious link in the chain of creation, and show the means in the lower classes by which the species is rendered so abundant; but in the class immediately following, in which the individuals are capable of impregnating themselves, there is a still greater security for the continuance of the species, as the ova, whatever their number, are sure of being impregnated.

This provision of nature has been hitherto considered to be confined to animals, whose genital organs were either very obscure or altogether invisible; but from the following observations, this appears by no means to be the case, since not only the lamprey, the myxine, the teredines, barnacles, and the worm in wheat, described by Bauer, are of that kind. Mr. Hunter took up this investigation in the common eel; but as they do not breed in our rivers, notwithstanding his perseverance, and employing persons at Gibraltar to afford him facilities, he was unable to come to any conclusion: this failure induced me to take up the enquiry in the common lamprey, as that animal is known to breed in our own rivers, particularly the Severn.

That the lampreys had distinct sexes no one doubted; for as these animals were found in two states, one with ova, the other without, those that had no ova were considered to be males; but although Sir Joseph Banks supplied me with lampreys from the Thames at different periods, I found

none without ovaria, although at one time very small, at another large, but never met with testicles.

Being accidentally sent for to Worcester in the line of my profession, during the lamprey season, I made an acquaintance with a very intelligent person, whose sole employment is to prepare them for being potted, which is considered to require no small degree of skill, in dexterously removing a black substance, believed to be poisonous.

Upon my pointing out to him the peculiar structure of the ovarium, he declared that in all his experience he had never seen one lamprey in which that part was wanting.

After such a declaration from a person of that experience, I could have no doubt of the lamprey being an hermaphrodite animal.

To satisfy myself, however, that I was not led into error, I got my friend, Dr. Wilson Phillip, then a physician at Worcester, to supply me monthly with lampreys, that I might prosecute this enquiry.

Upon examination of the two glandular bodies that have been hitherto considered as kidneys, one on each side of the ovarium, they were found to vary much in their size and appearance at the beginning and end of the season.

When the ova are so small that the animal is reputed to be a male, these glandular bodies, and the black substance upon which they lie, appear to form one mass, and the duct upon the anterior part is thin, and almost transparent, containing a fluid equally so; but in the end of May, when the ova increase in size, these glandular bodies become larger, more turgid, and have a distinct line of separation between them and the black substance behind; their structure is

more developed, being evidently composed of tubuli running in a transverse direction, and the ducts leading from them are thicker in their coats and larger in size.

On the fifth of June, the ova were found to be of the full size, and a small transparent speck, not before to be observed, was seen in each; at this time the tubular structure had an increased breadth, and the duct going from it contained a ropy fluid, which when examined in the field of the microscope, was found to be composed of small globules in a transparent liquid.*

On the ninth of June, neither the ova nor the tubular structure had undergone any change.

On the eleventh, the ova were of the same size, but the slightest force detached them from the ovarium; the tubular structure had increased still more in size; the fluid in the ducts was thicker, more ropy, and when water was added to it in the field of the microscope it coagulated, and what was before made up of globules had now the appearance of flakes.

As these specimens had been kept two days, and had been carried one hundred and twenty miles before they were examined, the appearance of the tubular part was seen under a disadvantage; but I was so fortunate, on the twelfth of June, as to receive from the late Sir Joseph Banks the viscera of two lampreys, caught in the river Thames, one of which had shed its ova, the other just ready to do so. In this last the tubular structure, from being in a more recent state, was very distinct, and the difference in texture and appearance

* Plate CXLIX.

between it and the black substance behind it was more strongly marked.

As the tubular structure runs up nearly to the heart, and may be said to lie principally behind the peritoneum, which is the situation and course followed by the kidneys in fishes, there can be no doubt that it performs the office of that gland, while the tubular bodies that project into the cavity of the abdomen, and enlarge to double their usual size, at the time of the ova being shed, must be allowed to be the testicles.

The ova in the lamprey do not pass out at an excretory duct, as in fishes; they drop from their cells in the ovarium into the cavity of the abdomen, and escape by two small apertures at the lower part of that cavity into a tube common to them, and to the semen, by which they are impregnated.

This mode of impregnation is so much more economical than in fishes, that the smallness of the magnitude of the testicles is sufficiently explained.

So great is the resemblance of the common eel to the lamprey, and of the conger to the common eel, that there was little reason to doubt of their mode of generation being the same. That the conger and eel are of the same species, only one a salt-water, the other a fresh-water animal, Sir Humphrey Davy has long been satisfied. Last year he caught a healthy eel, and has kept it now for a year in sea-water. It not only has thrived in this situation, but as it has been regularly fed it has encreased considerably in size; and he is assured by the person who has the charge of it, that the colour has begun to undergo a change, bearing a

greater resemblance to the conger than to the eel. This experiment is carrying on upon the coast of Cornwall.

To determine the similarity of the mode of generation of these three animals, I requested Mr. Bauer to make the annexed magnified drawings of the lamprey, just before it sheds its eggs, and some time after they are shed*; I also afforded him an opportunity of examining the organs of generation of the eel, and conger. In the beginning of February, one conger had ova readily seen in the microscope, but two others caught at the same place had none so far advanced.

In the common eel and conger there was this difference from the lamprey; the two kinds of eel have an air-bladder, the lamprey has none; consequently the ovaria in the conger and common eel are spread on the side of the air-bladder, and in these eels the kidney lies more behind the vas deferens, and the peritoneum covering it is of a more compact structure.

The myxine, and another animal from the South Seas, evidently of the same tribe with the lamprey, have organs of generation with a similar structure.

The teredines, as animals in some respects inferior in their organization to the lamprey, I shall place immediately after them, confessing, at the same time, that a knowledge of the mode of breeding of this tribe led me to discover that of the lamprey.

The organs of generation are very simple, and readily ascertained. The testicles are situated on the outside of the

* Plate CL.

stomach, and the ovaria lie behind and between the gills; the ducts from the testicles pass along the edge, and terminate near the base of the small tube, so that the ova are impregnated before they pass out at the orifice.

Sellius mentions that the ovaria are full of eggs in the spring, and they are even met with in December, but in February the ovaria are empty. This is confirmed by the specimens of wood from Sheerness, filled with teredines, in February, having the ovaria empty, and the testicles so small as not to be distinguished.

In specimens of teredines in the collection of this College, on the other hand, the ovaria formed two ridges, so conspicuous were the ova, and the testicles were large.

The barnicle has had its anatomical structure examined by Hunter and Cuvier; but both of these great anatomists were so unfortunate as not to meet with the lepas anatifera in the breeding season: this prevented them from seeing the mode in which the ova are disposed of, till they are hatched, and consequently misled them in the physiology of the other parts.

The ovaria are situated round the œsophagus, and may, in the unimpregnated state, be mistaken for the salivary glands; and the penis may either be considered as oviduct or penis.

The curious circumstance in the anatomy of the lepas anatifera is, that the ova are impregnated before they leave the ovaria, by the point of the penis being bent down, and carried for nearly a quarter of an inch into the ovarium; and after impregnation the ova pass through a small opening in the manteau into the stem, by which the body of the barnicle is suspended: in that situation the ova are both defended

and supplied with salt water; and when the embryo is completely formed, it makes its way out laterally from the stem, leaving the shell or covering of the egg behind attached to the inside of the tube, marking the place from which it escaped; the young lepas then acquires a stem of its own. In some cases, as shown in the drawing, the embryo comes out at the root of the shell.

All these circumstances are beautifully illustrated by the annexed drawings.*

The last of this class of self-impregnating animals which I shall notice, is the vibrio tritici, met with in the ears of wheat; Mr. Bauer having allowed me to take extracts from his account of it † published in the Philosophical Transactions.

On the Vibrio Tritici.

This minute animal is the cause of the destructive disease in wheat, known by the name of ear-cockle, or purples, by the farmers.

On opening some of the diseased grains, I found their cavities filled with a mass of a white fibrous substance, apparently cemented together by a glutinous substance, and formed into balls, which could easily be extracted entire from the cavities of the grains, and which, when immersed in water, instantly dissolved, and displayed in the field of the microscope hundreds of perfectly organized, extremely minute worms, which were in less than a quarter of an hour all in lively motion.

* Plates CLI. CLII. CLIII. CLIV.

† Plates CLV. CLVI.

Having left some of these worms on a glass for five days in a perfectly dry state, they were apparently dead, but when moistened, they were, in less than half an hour, again as lively as ever.

These experiments and results were so far satisfactory, as they incontestably established the fact, that the fibrous substance within the cavities of the diseased wheat-grains consists of real organized animals, which are endowed with the extraordinary property to have their muscular actions suspended for a considerable length of time, and to have it renewed again by the mere application of moisture; but how these animals are propagated, and how they are introduced into the cavities of the young germes, appeared to me a mystery, which I was convinced could only be unravelled by tracing them through every stage of the germination and vegetation of the growing plant of wheat; and believing that the eggs of these worms must be conveyed into the cavities of the very young germens of the flowers of wheat by the circulating sap, in the same manner as the seed of the parasitical fungi, which occasion the well-known disease in wheat, the smut-balls, and which I have in former experiments successfully inoculated upon sound wheat, I determined to try the same experiment with these worms; I therefore selected some sound grains of wheat, and placed some portion of the mass of worms in the grooves on the posterior sides of the grains, and planted them in the ground in the month of October, 1807.

The seeds soon came nearly all up, and I took from time to time some of the young plants for examination, but could not perceive any effect of the inoculation, till in the month

of March, 1808, when, in carefully slitting open the short stalk of a young plant, I found three or four worms within it: they were in every respect the same, but they were now about two-thirds larger, as well in length as in diameter.

On the fifth of June, I found, for the first time, some of the worms of different sizes within the cavities of the young germens; and having, in the beginning of March, found some of them in an enlarged state in the stalks, I concluded that some of the original worms with which I had inoculated the grains of seed had got during the germination of the grains into the stalk, where they became mature, and laid their numerous eggs there, some of which must be carried by the circulating sap into the cavities of the then forming young germens, in which the young worms extricate themselves from these eggs, and finding their proper nourishment within the cavities of the germen, these young worms become of a mature age and lay their eggs within the cavities of these germens, which at that period nearly approach towards maturity; and these newly-laid eggs I consider to be the beginning of the third generation of the worms with which I had inoculated the grains which I planted in the ground in October, 1807.

Since the fifth of June, I regularly examined every second or third day an ear, to observe the progressive advancement as well of the worms as of the germens: towards the end of June they assumed various distorted forms, and began to be filled with eggs. I extracted carefully the whole contents of one of the largest grains, and putting it into water in a watch-glass, I found on examination, under the microscope, seven large worms, a great many eggs, and at least a hundred

young worms all alive, bending and twisting in the water like so many small serpents.

The natural size of the largest of these seven worms I found, by means of the micrometer, to be something more than one-fourth part of an inch in length, and about $\frac{1}{80}$ part of an inch in diameter. They are more of a yellowish white colour than the young worms, and not so transparent: their heads are very distinct: they have a kind of proboscis, which has three or four joints, which they contract or extend like an opera-glass. From the head, which is somewhat roundish, they taper gradually off towards the tail, which is scarcely half the diameter of the middle of their body, and ends in an obtuse clawlike point. At a short distance from the end of the tail is an orifice, surrounded by an elevated fleshy edge; from this orifice the worms discharge their eggs.

The back of these old worms is nearly opaque, and appears jointed or annular: the number of joints or rings is from twenty-five to thirty: the belly-side is more transparent; and the strings of ova can be distinctly seen through almost the whole length of the worm, to the orifice by which the eggs are discharged.

The movements of these large worms are very faint and slow: they are very seldom observed to unroll themselves entirely: they move their heads and tails faintly, but their probosces they move constantly, extending and contracting them quickly; and when in the act of discharging their eggs, they bend the tail-piece upwards with a very quick jerk, at the passing of every egg: after having discharged all their eggs, the parent-worms soon die, and in a few days they decay and fall to pieces almost at every joint.

The eggs come out of the orifice in strings of five or six, adhering to one another at their ends, which then appear truncated, but in water they soon separate and assume an oval form, which in its middle is slightly contracted. These eggs consist of an extremely thin and transparent membrane, through which the young worm can be distinctly seen, and if attentively observed, may be seen moving within this envelope. The egg is about $\frac{1}{300}$ part of an inch in length, and $\frac{1}{800}$ or $\frac{1}{900}$ part of an inch in diameter.

In about an hour and a half after the egg is laid, (at least those in water,) the young worm begins to extricate itself from it: one extremity of the worm (which I consider to be the head) comes out at one end of the egg, and by continual twisting and active exertion the young worm comes gradually entirely out. I watched one individual from the first appearance of the head till it was entirely extricated, which it effected in one hour and twelve minutes.

The eggs, after the worms are come out, soon shrivel and decay; and it seems they ultimately dissolve, as in a very few days they entirely disappear, as well those in water as those that have been hatched within the germen.

The young worms are somewhat smaller and more transparent than those which are found in the more minute grains, but in a very short time after they have mixed with the others, cannot be distinguished from them. Those which are found in the cavities of the mature grains are nearly all of the same size; they are from $\frac{1}{33}$ to $\frac{1}{16}$ part of an inch in length, and $\frac{1}{1200}$ part of an inch in diameter: they are milk-white, semi-transparent, and, if viewed with the strongest magnifying power, appear annular like the large

worms, though no external indentations are observable: they appear like fine glass-tubes filled with water, and containing many air-bubbles in close succession, and of the same number as the rings or joints in the old worms. At both extremities (one of which is more sharply pointed than the other) there are no such divisions or joints perceptible: these extremities are each about one-eighth of the whole length of the worm; they are perfectly transparent, and appear like solid glass.

Respecting the sex of these minute animals, I could never discover any external distinction.

The old worms in the same germen are almost every one of a different size: they have all the same proboscis, and the same orifices.

Three of the seven worms, from the same grain which I first examined, were laying their eggs at the same time, though they were not of the same size; but the other four were not: they were considerably smaller, and evidently much younger; but I have not the least doubt, had they been left undisturbed in the grain, they would at the proper period have attained the same size as the others, and would have produced eggs. In this case they must be hermaphrodite, an opinion confirmed by my subsequent investigations of grains approaching nearer to maturity: in them there was no such striking difference in size. At that period, the old worms in the same grains, which probably laid their eggs first, were now in a decaying state: some parent-worms were found dead, and those still alive were laying eggs of the same size. I also found that the infected germens in the upper part of the ears very frequently contained only one single

large worm, and these germens were gradually filling with eggs, in the same manner as those in which originally there was no more than one worm; and among the diseased germens of plants which I had inoculated with the worms and the fungi of the smut-balls, both diseases having taken effect, I found several germens containing two or three large worms, which formed as many distinct nests within the same germen, having each of them a large distinct cluster of eggs kept separate, by the fungi of the smut-balls that occupied the cavities within these germens.

At the latter end of July, the diseased grains had almost attained their full size, and assumed a brownish tint; about the fifth of August, they became of a dark brown colour, and as hard as wood. The cavities of these grains were now completely filled with young worms, similar to those with which the first seed grains had been inoculated, which were now more than a year old, and consequently the grains and worms within them were completely dry; but after soaking them in water about an hour, the worms recovered their power of moving, and were as lively again as those which were taken from the living plants.

These experiments I repeated with grains from the same specimens for five years and eight months, always with the same success; but I observed that the longer the grains were kept dry, the longer were they required to remain in water for the worms to recover motion: but after the expiration of five years and eight months the worms were really dead.

The worms of the specimens which were the produce of my inoculated plants retained their reviviscent quality for six years and one month; and this is the longest time of

suspension I have hitherto ascertained: after that time they remained dead.

The large worms after they become dry die, and never revive; neither can the young worms within the eggs be revived, if the eggs have been but for a moment dry before the worms have extricated themselves.

Experiments with such worms as had been revived in water before and had been dried again, I repeated many times: I soon found that those which had been kept the shortest time in water recovered their motions soonest, so that those which had been examined on the plain object-glass, where only a very small quantity of water can be applied, which very soon evaporates, almost every individual worm recovered in less than in a quarter of an hour; and if the water is a second time suffered soon to evaporate, the experiment may be repeated many times successfully with the same specimens of worms; but after the second or third repetition, if there is a suspension of a week or ten days at each interval, several worms do not revive, and the number increases every succeeding repetition. If this experiment is not repeated too soon or too frequently, the worms retain their reviviscent quality much longer: the longest period of recovery, after a second suspension, I have hitherto ascertained, was eight months.

If the worms are kept alive in water for a week or ten days, the experiment cannot be repeated so often, but the intervals of suspension may be prolonged considerably. I made the experiment very recently with grains, which were three years and ten days old and dry. After extracting the worms from the grains, I kept them in water thirty-five days,

and after they had again been fifteen days perfectly dry, I supplied them with water, and in less than twelve hours' soaking, they were again, almost every individual, in as lively motion as if they had been taken from fresh grains of the growing plant, I had the pleasure of showing these worms in that state to several members of the Society, on the twenty-ninth of September last: after that day I preserved the same specimens eighteen days perfectly dry, and supplying them with water, I found in less than three hours at least one-third of them in a lively motion; but the next morning, after they had just been sixteen hours in water, they were all dead.

If these worms are kept in a large glass where the water cannot evaporate, they remain alive more than three months, but then they gradually die in the water, and become as straight as needles: in that state they remain unaltered in size and shape for more than fourteen months, and even after that time I found very few floating on the surface of the water, which appeared in a state of decay: they were then much thinner than they had originally been, and were shrivelled at every joint, the number of which could now be distinctly ascertained; the worms then became of a brownish colour, and at the least touch, or the slightest agitation of the water in which they are kept, fall to pieces almost at every joint.

If the worms of one grain are put into water in a watch-glass, they generally separate and spread over a surface of about an inch in diameter; but during night, or if kept some hours in a dark place, they all assemble again, and twist themselves together in a round cluster, the same as they

originally formed within the cavity of the grain: the same glutinous substance by which they were cemented together, whilst within the grain, surrounds and envelopes them again; and if they are suffered to get dry in that state, they retain their reviviscent property for as long a time as if they had been preserved within the grain.

The above mentioned glutinous substance appears to be of an oily nature; for if a cluster of the worms is extracted from the grains, and is slightly rubbed on the object-glass, it leaves a stain on the glass, which, if viewed through the microscope, appears to consist entirely of a clear and colourless fluid, which neither evaporates nor dries on the glass after several months; but if the cemented mass of worms is immersed in water the clear fluid almost instantaneously dissolves, and the worms separate.

If the worms are kept in a considerable quantity of water, and the water is frequently changed, the worms very soon die in the water, or if taken out whilst yet alive and suffered to dry on the glass, they remain dead; but if the young worms are kept only in a moderate quantity of water, in a watch-glass, the mucus or glutinous substance rises, and in about twelve hours forms a film on the surface of the water, and soon becomes nearly opaque, and sinks again upon the worms at the bottom of the glass, and in that state the worms continue alive more than two months; but if that film is carefully scummed off, the worms in the water die in less than twelve hours.

This glutinous substance must be secreted by the worms, since in grains in which the worms and the fungi or smut-balls exist, that portion of the cellular tissue of the young

germens, where a worm has formed its nest and laid its eggs, is entirely preserved, whilst in those portions of the grains which are immediately in contact with the fungi, the cellular tissue disappears, and the fungi are only enveloped by the external tunic of the young germen.

From these facts we are to consider this glutinous substance the probable cause of preserving these minute animals for such a length of time.

LECTURE XIV.

The Changes the Egg undergoes during Incubation.

THE doctrines I imbibed from Mr. Hunter in the earliest part of my education were, that the blood is the first part formed, and it is in that fluid the principle of life is contained.

Mr. Hunter went so far as to consider brain and nerves not only unnecessary for the economy of the animal with respect to the functions of its internal organs, but looked upon them as an incumbrance, drawing their nourishment from the blood, and in return, by means of the senses, keeping up a communication with external objects which could not otherwise be done, and thus increasing the power of procuring supplies.

So much was my judgment warped by this theory, that when the human ovum was first discovered I considered the two projections seen through its coats to be the rudiments of the brain and heart, believing that these important organs

must be coeval with one another, if the heart was not first formed.

Every step I advanced in comparative anatomy induced me to view the brain and nerves as more important organs, and to consider the blood, the heart, and the arteries, as subservient to the influence of the brain. This must have been obvious to my audience from what I have stated in many of the preceding Lectures.

I reconsidered the subject again and again; I examined the preparations in the Collection on the earliest stages of incubation; and so much did the first appearance resemble that of incipient rudiments of brain, that had it not been for the following expressions used by Mr. Hunter in his work on the Blood, and Inflammation, I should have been satisfied that I had mistaken his meaning; and the error of giving the blood a preference was my own; but it is impossible not to understand the explanation of the first figure in the first plate in that work. "The only parts formed are two blood-"vessels; on each side of these is a row of small dots or "specks of coagulated blood, which are afterwards to become "blood-vessels."

After the human ovum had been demonstrated, showing the molecule upon a larger scale than it can be ever seen in the bird, and in the two separate stages before and after impregnation, I became exceedingly desirous to induce Mr. Bauer to enter upon the investigation of the incubation of the hen, which he has most happily done, whatever difficulties he had to overcome, and whatever labour he had to bring to the work.

Although this is a subject to which the great Hervey,

Malpighi, and Hunter, applied their whole strength, there were three disadvantages they could not overcome; which Bauer had not to contend with: 1st, They had not previously examined the human molecule, they therefore had not the first point established; 2dly, They had not been inured to microscopical examinations so as to bring them to perfection; and, 3dly, they could not with accuracy delineate what they saw, but were obliged to resign that office to another.

Under these disadvantages, it is rather to be wondered at, that they did so much than that more was not effected; and when we examine the series of preparations in the Collection of the College on incubation, had Mr. Hunter done nothing else, that alone would have established his reputation for accurate minute investigation beyond other anatomists.

Mr. Hunter's account of the process of incubation is certainly much more satisfactory than either that of Hervey or Malpighi. His having fallen into the error of believing the blood and its vessels the first formed, gives Malpighi an advantage over him, who asserts it to be the brain.

Mr. Hunter began his investigation before 1773, and finished it before 1780. The French anatomists have very recently applied themselves to this subject.

Mr. Dutrochet laid a Memoir before the French Academy in the year 1815, which has not, I believe, been published; but Mr. Cuvier has given a report upon it highly flattering to the author, and compliments him upon being the first person who has explained the rise and progress of the vesicle which afterwards envelopes the embryo.

There is, however, in Mr. Hunter's remarks an account of the mode in which that vesicle has its origin, and the use to which it is applied; but neither Hunter nor Dutrochet have traced it in such a way as to preclude the necessity of the following observations to make the subject understood.

Having stated that all which has been done by those who preceded me in this enquiry has fallen short of the object which it was my wish to ascertain, I shall now, before I proceed to give an account of Mr. Bauer's microscopical observations, explain more precisely what that object is. We now know that the human ovum and that of quadrupeds consist of a semi-transparent elastic gelatinous substance, enveloped in two separate membranous coverings; that this jelly is formed in the ovarium independent of the male influence, and that after the application of that influence to this molecule many changes are produced; what immediate changes take place in the quadruped have not been ascertained. I was desirous of determining whether a similar molecule exists in the yelk of the hen's egg in its first formation, even before it enters the oviduct, and whether it has a similar appearance, also of tracing with the greatest accuracy the changes which take place after the influence of the male has been applied to it, so as to ascertain, if possible, in what the first visible alteration consists, whether, in truth, a punctum saliens is formed, and this in its increase becomes the heart; or the rudiment of the brain and spinal marrow are previously developed.

That none of these points are satisfactorily established at present will, I believe, be readily granted; for although many of the facts I shall bring forward entirely accord with

opinions already published, still those opinions require confirmation; and as the drawings to illustrate every statement that will be advanced are exact copies from nature made by one who had no previous knowledge on the subject, and therefore who could not be misled by any preconceived opinion, they will establish by their accordance many things that before remained doubtful.

The simplest mode that I can adopt of laying this investigation before my audience, will be to give the facts in detail from the first formation of the yelk to the chicken's leaving the shell, and providing for itself.

The gelatinous molecule, from which the future embryo is to be formed, is originally met with on the surface of the yelk; it is found there before the yelk leaves the ovarium, and lies in contact with it, not being enveloped in any capsule.

The external membrane of the yelk, when it leaves the yelk-bag, is very thin and delicate; its surface is studded over with red dots, which disappear in its passage along the oviduct. When this membrane is removed, there is a second thick and spongy covering under it, in which there is a natural aperture, through which is seen the molecule, surrounded by an areola. Upon examination the areola proves to be nothing more than that part of the surface of the yelk that is circumscribed by the margin of this aperture. No such aperture has been before taken notice of.

The molecule itself has a granulated appearance; in the centre it is made up of globules $\frac{1}{2800}$ part of an inch in diameter, surrounded by circles of a mixed substance, consisting of about two-thirds of the same small globules, and

one-third of larger oval globules, about $\frac{1}{1600}$ part of an inch in length, and $\frac{1}{2000}$ part in diameter; these last, in their figure, resemble the oval red globules of the blood in the bird in every respect, excepting their red colour. Besides the globules there is some fine oil, which appears in drops when the parts are immersed in water. Oval globules and oil are also met with in the yelk itself, but in small proportion, and without colour.

All these parts, except the red dots on the surface, are met with in the yelk on a smaller scale, even six days before it is completely formed.

The ovarial yelk-bag gives way at the middle line, farthest from the insertion of the blood-vessels, and the yelk drops out into the mouth of the oviduct.

The orifice in the yelk-bag does not immediately close, although it contracts considerably: some time after it is nearly obliterated, and on the pedicle, the rudiments of a new yelk are formed.

The yelk-bags are exceedingly vascular; the outer membrane of the yelks is connected to them by vessels and fasciculi of fibres, but is easily separated from them.

The yelk, while in the ovarium, has an oval form, and lies with its long axis towards the pedicle of the bag.*

In its passage along the oviduct the yelk acquires the albumen, and before it comes to the lower end, the albumen is covered by a very fine membrane.

In this passage the thread-like substances, called by Mr. Hunter the poles, by others the chalazes, are formed; and terminate in the double membrane, which is added at the

* Plate CLVII. fig. 1, 2, 3, 4, 5.

time the egg has reached the lower end of the oviduct. In the cloacus the shell is formed. If the egg is taken out before it has acquired a shell, it remains soft for several days; in one instance, after four days, it was so semi-transparent as to receive a yellow tint from the yelk. On puncturing the covering, the contents rushed out, but immediately resumed their form, being inclosed in the thin membrane of the albumen. The molecule with its areola, and the chalazes, were distinctly seen. The whole contents had less volume than the shell, particularly in the long axis, being truncate at both extremities. When immersed for an hour and half in distilled vinegar, the albumen and other parts had become somewhat coagulated.*

In the new-laid egg the appearances are exactly the same, whether it has or has not been impregnated by the male: the molecule is a thick semi-transparent jelly; and as its size appears to vary with that of the egg, any slight shade of enlargement after impregnation was not apparent, particularly when the mind was not prepared for marking such a circumstance.†

When the shell and membranes under it are removed from one side, the yelk appears to be kept in its place by the poles, although allowed to rotate upon its axis.

The gelatinous molecule, with its areola, is always found upon the highest point of the upper surface of the yelk. Whether this arises from the molecule, or from the part of the yelk immediately surrounding it being the lightest, has not been ascertained.

* Plate CLVII. fig. 6, 7, 8, 9.

† Plate CLVII. fig. 10, 11, 12.

When the hen begins to sit, a new-laid egg, which has not been allowed to cool, will have the rudiments of the embryo formed some hours sooner than in the other eggs.

Having traced the formation of the egg itself through all the changes that take place from the time the yelk leaves the ovarium till it is impregnated, we shall now follow those changes that are met with during incubation till the embryo becomes a completely formed chicken.

In four hours after incubation the outer edge of the areola had become enlarged, and that part of it next the molecule appeared darker. One end of the molecule appeared like a white line, the first rudiments of the embryo.*

In eight hours, the white line was found to be extended, and the rudiments of a brain and spinal marrow were formed, surrounded by a membrane, which afterwards becomes amnion.

The areola had extended itself, and the surface beyond the line which formed its boundary had acquired the consistence of a membrane, and had also a distinct line by which it was circumscribed. This I shall call the outer areola. In the space between these two areolas, there were distinct dots of an oily matter. This extension of membrane to the outer areola is beyond the aperture, and lies under the inner membrane of the yelk; it can readily be removed entire.†

In twelve hours, the rudiments of the brain were more distinct, as well as of the spinal marrow. These parts were

* Plate CLVIII. fig. 1, 2, 3. † Plate CLVIII. fig. 4, 5, 6.

placed upon a black ground in vinegar, and hardened; the upper end showed the tuberculum annulare of the brain, from which passed down two semi-transparent lines resembling an appearance peculiar to the spinal marrow of the bird.*

In sixteen hours, there was a farther advance in the structure of all these parts.†

In twenty-four hours, a still greater increase.‡

In thirty-six hours, the head was turned to the left side. The cerebrum and cerebellum appeared to be distinct bodies; the iris was seen through the pupil of the eye. The intervertebral nerves were nearly completely formed; those nearest the head the most distinct. A portion of the heart was seen.

At this period, under the inner areola, apparently at the termination of the spinal marrow, a vesicle had begun to protrude. In some eggs it is seen earlier than in others, and has been observed before the heart had become visible.§

In two days twelve hours, the spinal marrow was found to have its posterior part enclosed: the auricles and ventricles of the heart were seen, the auricles filled with red blood. An arterial trunk from the left ventricle gave off two large vessels, one to the right side of the embryo, the other to the

* Plate CLVIII. fig. 7, 8, 9.
† Plate CLIX. fig. 1, 2, 3.
‡ Plate CLIX. fig. 4, 5, 6.
§ Plate CLIX. fig. 7, 8, 9.

left, sending branches over the whole of the areolar membrane, which was bounded on each side by a large trunk carrying red blood; but the branches of the two trunks did not unite, there being a small space on one side rendering the circle incomplete: this I shall call the areolar circulation.

The vesicle was somewhat increased in size; it lay in the lower part of the abdomen, the parietes of which were not yet formed.*

In three days, the outer areola had extended itself over one-third of the circumference of the yelk, carrying the marginal arteries along with it to the outer edge, but diminished in size. The brain was much enlarged, consisting of four cavities containing a fluid, the cerebellum still the largest. The spinal marrow and its nerves were more perfectly formed. The eye appeared only to want the nigrum pigmentum.

The right ventricle of the heart contained red blood: the arteries could be traced to the head: the rudiments of the wings and legs were formed: the vesicle was farther enlarged, but its vessels did not carry red blood. It had forced its way out through the external covering of the yelk, and opened a communication through this slit, by which a part of the albumen was admitted to mix itself with the yelk, and gave it a more oval form. At this period the embryo is generally found to have changed its position, and to be wholly turned on the left side.†

In four days, the vesicle was more enlarged and more vascular, its vessels containing red blood.

* Plate CLX. fig. 1, 2, 3.

† Plate CLX. fig. 4, 5, 6.

The optic nerve and nigrum pigmentum of the eye were visible; the other parts had become more perfectly formed.

The outer areola had extended itself half over the yelk which had now become still more increased in size, a greater portion of albumen having become mixed with it.*

In five days, the membranous bag that formed the vesicle had acquired a great size and become exceedingly vascular in its coats; the yelk itself had become thinner in its consistence, more of the albumen having been mixed with it.†

In six days, the vascular membrane of the areola had extended farther over the yelk.

The vesicle at this time had suddenly expanded itself in form of a double night-cap over the yelk, and its coverings were beginning to enclose the embryo. This change is so rapid as to be with difficulty detected. The amnion contained a fluid in which the embryo was suspended by the vessels of the vesicular membrane.

The brain had become enlarged so as to be equal in size to the body of the embryo; its vessels were distinctly seen. The two eyes equalled in size the whole brain: the marsupium was covered by nigrum pigmentum. The vessels of the cerebellum could be traced into the convolutions.

The parietes of the thorax and abdomen had begun to form; the wings and legs were nearly completely formed,

* Plate CLX. fig. 7, 8, 9.

† Plate CLXI. fig. 1, 2, 3.

as well as the bill. At this period muscular action was first noticed.*

In seven days, the vesicle having extended over the embryo, had begun to enclose the areolar covering of the yelk, and a pulsation was distinctly seen in the trunk that supplied the vesicular bag with blood. The pulsations were seventy-nine in a minute, while the embryo was kept in the temperature of 105°; but when the temperature was diminished, they ceased, when again raised to the same point, the pulsation was reproduced: by keeping it up, the pulsation continued thirty-six hours. The muscles of the limbs now moved with vigour.

When the embryo was completely immersed in the water at 108°, the pulsations immediately ceased.†

In eight days, the anastomosing branches of the vesicular circulation had strong pulsation in them.‡

In nine days, the vesicle had nearly enclosed the yelk, but not entirely; for when the embryo was turned upon its back and the opposite surface examined, a portion of yelk was uninclosed; and beyond it, some of the albumen was met with not mixed with the yelk.§

In ten days, divided the vesicle through both its membranes, and turned aside one half. When the embryo was

* Plate CLX. fig. 4, 5, 6.
† Plate CLX. fig. 7, 8, 9.
‡ Plate CLXI. fig. 1, 2, 3.
§ Plate CLXI. fig. 4, 5, 6.

taken out of the amnion, which had become full of water, the thorax was found completely formed: the roots of the feathers were very distinct.

The contents of the egg having been much diminished, during the formation of the embryo the void space had been gradually filled with a gas: this was examined by Mr. Hatchett, and found to be atmospheric air, deposited at the great end of the egg, between the lares of the membrane lining the shell.

Even before incubation is begun, there is always a small portion of air in this place, which undoubtedly is rarified by the heat of the mother, and employed in aerating the blood from the time of its first acquiring a red colour, till it is superseded in that office by the external air through the egg-shell acting upon the blood in the vessels of the vesicular membrane with which it is lined.

In fourteen days, the yelk remained out of the body, when the thorax and abdomen were opened, and the heart as well as the lobes of the liver were turned aside: the trunks of the blood-vessels were seen arising from the heart; but as the arteries immediately after death become empty, and the veins continue full, the vesicular vein terminating in the auricle, and the areolar vein terminating at the portæ of the liver, were alone conspicuous.*

In eighteen days, the greater part of the yelk was drawn into the body.†

* Plate CLXII. fig. 1, 2, 3.

† Plate CLXIII. fig. 1, 2, 3.

In twenty days, the chicken was completely formed: the yelk was entirely drawn in*, and only portions of the membrane belonging to the vesicle were seen externally. The yelk-bag had a narrow tube half an inch long, connecting it to the intestine eight inches above the openings of the cœca into the gut; this tube entered the intestine in a direction obliquely downward.

The cœca were two inches long, half full of a dark-coloured substance of considerable consistence, the tube from the yelk-bag being empty †; so that the cœca in the bird appear to furnish a secretion of their own, an opinion I advanced in the former volume.

Having examined the human ovum, and afterwards gone through this investigation in that of the bird, I shall in this place make the following remarks:—

That in all animals formed from an egg, the molecule exists previous to incubation, and belongs wholly to the female, but requires something being actually applied to it from the male, before it can be possessed of vitality; so that the future embryo partakes in reality of both the male and female parent, which explains the progeny bearing resemblance to them, although in different degrees. In the instance of superfœtation in the dog, the influence of the males had been predominant, since two of the puppies were so like the two males as to make it remarkable; but neither of the others had a close resemblance to the mother. I have met with a similar instance in our own species. A black man, who is married to a white woman, brought me his wife and child to look at. I immediately remarked to him that I

* Plate CLXIV. fig. 1, 2, 3.   † Plate CLXV. fig. 1, 2, 3, 4.

had never seen a mulatto so dark; and he answered, that his sister's children by a white man were much fairer than his. In both cases the male influence predominating in giving colour.

The first change the molecule undergoes in the egg of the fowl after impregnation is not immediate; for when the molecule is examined, just before the hen begins to sit, its appearance is not changed from what it was before impregnation, at least it is not perceptible: under the circumstances in which it is placed, no small increase of its volume could be identified.

In the human ovum, we have shown its form both before and after impregnation. The moment it was enclosed in its amnion, we must consider that it had arrived at its full size, although the chorion was not completely formed; and yet when we compare the ovum before impregnation, delineated in the most accurate manner upon a micrometer, with one a day or two after impregnation, where there had been no means of its acquiring bulk from any new connection of parts, as it had not procured an attachment to the uterus, it was not only evidently larger, but had formed within itself two centres from which future operations might originate. A similar change in the molecule in the hen's egg was detected eight hours after incubation.

That the principal object of this investigation was to determine whether the first rudiments of the embryo were to be met with in the heart or brain has been already declared; and it is impossible, when the drawings are examined, not to decide that the parts first formed bear a resemblance to brain, and that the heart and arteries are produced in consequence of the brain having been established.

There are three other objects, which, although of a secondary nature, are yet of importance, which are most satisfactorily explained. These are, first, the mode in which the embryo in the hen's egg originally receives its nutriment from the yelk on which its rudiments lie, before heart and arteries have existence; secondly, the manner in which, at this stage, these rudiments of the embryo are aerated by the reservoir of air in the cavity at the great end of the egg; and thirdly, when the heart and its vessels are established, the mode by which the aerating system through the shell is produced, by the vesicle being protruded through the external covering of the yelk, and carrying branches of the aorta in contact with the lining of the shell.

As soon as this was discovered by Mr. Detrochet, and the discovery applied by Mr. Cuvier to animals in utero, they had made out the mode of aerating the embryo; and I have much satisfaction in confirming to them this credit, which they so well deserve, and only take to myself the elucidation of this intricate subject, which my acquaintance with the original state of the human ovum enables me to do.

For want of this knowledge, neither Cuvier nor Detrochet could know that although in the bird it is the outer membrane of the yelk that is burst by the vesicle, the inner membrane having a natural aperture; in the human ovum, and that of the quadruped, it is the inner membrane or amnion that gives way, the chorion never having been entirely closed.

The subject of animals being frozen, and afterwards recovering their vital functions, has been much agitated among philosophers. Sir Humphrey Davy, in the winter of 1821, froze a frog, which lost its life either in the act of freezing or thawing; since, when thawed, it was quite dead, and the irritability of the nerves was entirely destroyed, as they could not in the slightest degree be acted on by galvanism. The winter was too mild to afford an opportunity of determining whether this effect might not have arisen from the animal being too suddenly thawed.

In the frost of January, 1823, there was an opportunity, from the degree of cold and its continuance, to determine this point, which I took advantange of by making the following experiments.

At the time I made them, the present Lecture was actually in the press, and therefore the subject of the identity of the composition of the molecule in the hen's egg and the brain was constantly present to my mind, and induced me to continue the investigation by making those experiments upon the molecule which I am about to detail; and although the plates from Mr. Bauer's drawings had been engraved, I have added two figures to show the dissolved states of the molecule.*

On the Consequences attendant upon freezing the vital Parts of Animals, and of the Molecule in the Ovum of the Hen's Egg after Impregnation.

On the twentieth of January, 1823, the thermometer at 24°, I began the following experiments in the laboratory of the Royal Institution, assisted by Mr. Farrady.

* Plate CLXIII. fig. 4, 5.

Experiment 1.—At two o'clock, a lively frog had its head and fore-legs incased in tinfoil: its head was immersed in a cooling mixture standing at zero; a diaphragm of pasteboard, through which the body was passed, defended the other parts from the mixture, and they remained exposed to the open air. In twenty-five minutes, the exposed parts displayed violent muscular action: it was all of one kind; it consisted in stretching out the legs and toes to their utmost extent, then drawing them back again. In thirty minutes, this action ceased, and the animal became quiet. In forty minutes, the feet and toes were agitated a second time, but not the thighs. The muscular exertions were weak; and all at once the toes became fully extended, and afterwards remained so. Thinking the animal dead, I tried galvanism, with a trough of ten plates, one inch square, and diluted sulphuric acid; but no sensible effect was produced.

The frog was then placed in water at 60°. After remaining there one hour, every part of the animal appeared thawed, but could not be acted on by galvanism. The frog was then washed with cold water, and carried into the open air, and placed on white paper. The muscles of the leg were now under the influence of galvanism, when one wire was in the mouth, and the other applied to the nerve on the inside of the thigh: the abdominal muscles were also thrown into action. but none higher up in the body.

The galvanism had no effect on the feet while the brain and spinal marrow were rendered torpid, nor immediately after the animal was thawed; but in the course of half an hour, the nerves of the feet were influenced by galvanism.

On the next day the eyes were found sunk and destroyed: the fore-legs had become inflamed, swoln, and had several small spots of extravasation in different parts of the skin, appearances which were not present when the animal was first thawed; so that the heart had renewed its action after the frog was generally thawed.

The frog's feet and legs continued for four days to be under the influence of galvanism, but not higher than the muscles of the abdomen: at the end of that period, the animal was completely dead.

Upon examination after death, the brain was pulpy, and surrounded by water.

Exp. 2.—January 23., the atmosphere at 28°, repeated the former experiment.

At two o'clock the immersion of the head took place, the mixture at zero. In forty-five minutes, the legs and toes had become fixed in an extended state. The feet were galvanized. The animal remaining in the cold mixture, muscular contractions were excited by galvanism; but none without that stimulus.

When one wire was applied close to the pasteboard, the other to the toes, the muscular action was weak.

At the end of an hour, one wire applied high on the back, the other to the toes, produced no effect; but when applied lower down, the feet were acted on.

In one hour and ten minutes, no action was produced, unless one wire was applied towards the lowest part of the spinal marrow, the other to the toes.

In one hour and twenty minutes, all efforts to produce contraction by galvanism were ineffectual.

In this experiment the brain appeared to have become torpid in forty-five minutes, the spinal marrow in one hour and ten minutes, or twenty-five minutes later than the brain.

The frog was allowed to thaw in the temperature of the laboratory.

In twenty-four hours it was found dead; and on opening the skull, the brain was dissolved, and nothing remained but water.

Exp. 3.—January twenty-fourth. Atmosphere at 28°, the last experiment was repeated upon two frogs, placed in the same mixture, at some distance from each other. At the end of two hours they were both taken out.

The largest was split down, and the brain, heart, and stomach were found frozen; the hind legs and body of course were not at all frozen.

The other frog was kept in snow; so that at the end of four hours it was still stiff, and not acted on by galvanism. Next day, at the end of eighteen hours, the hind legs had recovered, and acted vigorously, when galvanized: the throat and nose had been inflamed, thickened, and blood in several places extravasated; appearances not present when first thawed. In two days the irritability strong to galvanism, but no voluntary motion.

On the fifth day died; and the brain, when examined, was found dissolved into a gelatinous liquid.

Exp. 4.—January twenty-fourth, 1823. The thermometer at 28°, two large healthy frogs were entirely wrapped up in tinfoil, and exposed to a freezing mixture at 0° for seven hours, the mixture having been renewed once in that time; they were then taken out of the mixture, but still enclosed

in the tinfoil, and buried in snow for twelve hours, after which they were placed in an atmosphere of 50° to thaw. In two days they were found thawed, but no part of their bodies were under the influence of galvanism.

At the end of two days one of them was dissected, but no excitement by galvanism could be produced, in whatever way tried, or whatever nerves exposed.

In the other, the brain and spinal marrow were found completely dissolved into water.

In neither of them had any inflammation taken place after thawing.

From the first of these experiments I was led to the conclusion, that when the brain was rendered torpid by cold, its influence upon the nerves was lost—but that while the spinal marrow was not affected, the irritability of the lower nerves continued, and the action of the heart went on; but when the spinal marrow became torpid, all irritability ceased.

That when the brain recovered from this torpor, the animal revived; but in those cases even where the brain never recovered, if the spinal marrow recovered, the heart renewed its action, and the nerves of the lower limbs recovered their irritability.

From the second experiment, all these conclusions were confirmed, and a new fact in physiology was brought to light; that the materials of the brain and spinal marrow, when thawed, after being frozen, in the act of thawing dissolve into water, and never can recover their organization.

From the third experiment the conclusion of the heart recovering its action after having been absolutely frozen is

completely confirmed, and the brain being dissolved does not prevent this from taking place, provided the spinal marrow is not frozen.

The spinal marrow, in those cases where the brain alone has been frozen and thawed, retains its irritability, or is under the influence of galvanism for the same length of time as in other cases where the brain has been completely removed.

This explains the fact noticed by several enquirers, that the removal of the brain without injury to the spinal marrow does not interfere with the action of the heart; but destruction of the brain by violence entirely puts a stop to it.

From the fourth experiment, the conclusion, that the brain of a frog when it has been frozen, is dissolved in the act of thawing, is completely established.

This very surprising fact did not astonish me so much, since I have for two or three years taught that the brain is made up of an elastic transparent gelatinous substance, soluble in water, intermixed with globules, varying very much in their size and distribution; a doctrine derived from Mr. Bauer's experiments and microscopical observations on the brain.

The moment it was discovered, that the brain after being once frozen, is dissolved in the act of thawing, it occurred to me, that I had now the means I despaired of ever possessing, to determine whether the material of the brain, and that of the molecule in the eggs of all animals, were in essence the same. I therefore got two fresh eggs, and marked the upper surface under which the molecule should be situated: I broke the egg-shell of one at that part, leaving the shell of the other entire: they were both wrapped up in tinfoil, with a mark on each, corresponding to that on the upper surface

of the egg; they were then exposed for sixteen hours to a cooling mixture at zero, after which they were put into snow to cool gradually, and in twenty-four hours examined by Mr. Bauer.

The egg-shell that was entire was not broken by having been frozen; the albumen was more than usually limpid; the molecule had its situation readily ascertained by the semi-opacity of the external covering of the yelk immediately over it, which was circumscribed by the margin of the aperture in the inner membrane; it had lost the usual projecting hemisphereal appearance, the surface having become quite flat; the membrane itself was shrivelled, and a number of air-bubbles were seen under it, collected round the inside of the circle: no remains of the substance of the molecule was met with under the membrane.

In the other egg, upon removing the external membrane of the yelk, some limpid fluid escaped with the air-bubbles, and nothing remained but a slight depression on the surface of the yelk.

In both eggs the molecule had been completely dissolved in the act of the egg thawing.

Mr. Bauer's microscopical drawings of these appearances are annexed.*

* Plate CLXIV. fig. 4, 5.

LECTURE XV.

On the Classing of Animals according to the different Means employed for the Nourishment of the Embryo.

Having gone through the different subjects in Comparative Anatomy which I had selected for the present course of Lectures, before I conclude, I shall, with the utmost diffidence, bring forward a sketch of a new scientific classification, comprehending the whole animal kingdom, which could not have been understood by my audience, had it not been preceded by the statements advanced in the foregoing Lectures.

Every step we advance in the acquirement of knowledge in Comparative Anatomy makes us better acquainted with the defects that exist in the general systems at present before the public. The truth becomes obvious, of there being no organ belonging to an animal, except the brain, that will bear us out in affording characters for a general classification, the structure of the other organs being varied, whenever it was necessary to adapt the animal to the climate which it is to

inhabit, or the food on which it is to subsist; and the brain we are not sufficiently acquainted with to take it as our guide.

In illustration of what I have advanced, the stomach in the rhinoceros of Java has a portion of its internal membrane covered with cuticle, that of the same animal in Africa has the whole of the internal surface villous. In the whale-tribe, the heart has its ventricles united as in quadrupeds, but in the dugong and manatee they are entirely distinct. The dugong, so like the manatee in other respects, has tusks which the other has not.

These deviations so constantly occur, that we are compelled to give up all idea of forming a system that can comprehend the various tribes of which the animal kingdom is composed, from an examination of the structure of their organs. This observation extends even to the organs of generation themselves, which are found to vary in an equal degree with other parts, adapting them to copulation upon land and under water.

There is only one fixed principle that admits of being laid hold of for this purpose, without which the whole scheme of nature would have been thrown into confusion: the principle I allude to is that which prevents animals differently constructed from breeding with one another at all, and does not allow those that are more nearly allied to carry on the breed beyond one generation.

Out of this principle the division into genera and species can be established upon sure grounds, and has been adopted by Linnæus.

In plants, whose organs of generation are, in general external, and therefore readily admit of examination, the mode in which the impregnation of the female takes place can be readily traced, and the evolution of the young plant can be followed through all its stages, without any outrage to the feelings of the botanist's humanity or delicacy, not even the annoyance of handling parts that can produce the slightest degree of disgust. This renders the enquiry attracting to the mind of every philosopher, and one which he can prosecute in his closet.

In botany, therefore, there is no wonder that the great Linnæus had the penetration to discover, that out of the laws of generation in plants a system of botany might be formed, superior to any which had been before his time promulgated; and we find his sexual system has stood its ground for nearly a century.

Since Linnæus's system was first adopted, the great fundamental improvements in botany have arisen from acquiring a knowledge of the formation of the ovula in plants before impregnation, the evolvement of these ovula after that process has taken place, and the developement of the embryo or young plant. For the advance that has been made in this the higher part, and what may be called the science of botany, we are under great obligations to Gærtner on the Continent, and to Robert Brown in England: the merits of both have very justly raised them to the highest estimation in every part of Europe.

These men, by their labours as practical botanists, had arrived at the same point in the anatomy of plants which

we have now acquired in Comparative Anatomy, by the discovery of the ovum in the human species. The ovula of plants was to them what the molecule in the ovum of the human species and quadrupeds is to the anatomist; and till that knowledge was acquired, and the addition given in the act of impregnation was known, with the consequent process to be gone through by which the molecule was to become an animated being, no attempt could be made by the most intelligent physiologist, not even by a Hervey or a Hunter in former times, or a Cuvier in our own, to form the scheme of a general classification upon the principle which is now brought forward.

The idea of such a scheme originated in finding, that the human ovum and that of quadrupeds consisted entirely of the molecule:—

In the kanguroo, that this molecule at its origin was under the same circumstances, but that an addition is made to it before it arrives at the uterus, and in that cavity it is furnished with albumen:

In the opossum of America, the molecule at its origin has a yelk connected with it in the ovarium, and in the uterus is supplied with albumen:

In the ornithorhyncus, the molecule has a yelk connected with it in the ovarium, receives albumen in the uterus, passes through the vagina, and at the cloacus is covered by a calcareous shell, and passes out of the body before it is hatched:

In the bird, the molecule has a yelk connected with it in the ovarium; there being no uterus its supply of albumen is in the oviduct, the shell is formed in the cloacus, and the egg is hatched out of the body.

So beautiful a series, each link having a marked distinction from the others, while it formed with them a connected series, made a strong impression upon my mind, as opening a new field of observation, out of which a correct general classification of animals could be formed. The more I thought of it, the more it delighted me; but at the same time I became more alarmed at the magnitude of the undertaking, and resisted the temptation held out of making an attempt in which the chances of success were so much against me. To relieve myself from the perplexity into which I was thrown, I wrote to Sir Joseph Banks, then in Lincolnshire, a candid statement of all that was passing in my mind upon this subject. Sir Joseph, in his answer, requested that I would not abandon the idea, for although to him it appeared a most arduous undertaking, there was much to be said in its favour.

Encouraged by the scheme I had formed, being viewed in a favourable light by one whose judgment I had always considered greater than that of other men, I went on collecting materials, and became less reluctant in giving my attention to this subject, till at last I yielded to an impulse by which I confess myself to have been fascinated. Unfortunately, soon after my resolution was taken, the death of my much respected, much valued, and esteemed friend, under the shadow of whose wing I had prosecuted so long the pursuits of Comparative Anatomy, deprived me of that able support, of which I felt that I so much stood in need, and from none but him could receive.

In these remarks my object has been to show that I am fully sensible of my own want of power for such an undertaking, and that I feel exceedingly the loss I sustain

in the death of Sir Joseph Banks. Had that melancholy event taken place before the present new classification had met with his approbation and encouragement, it would never have been brought before this audience, nor met the eye of the public.

Having said so much respecting myself, expressive of the diffidence which I feel in attempting the promulgation of a system of such magnitude and extent, I may be allowed to say a few words respecting the system itself.

It may be remarked that such a classification must be confined to men of science, and will require ages to bring it to any degree of perfection, in the most moderate signification in which that term can be used.

In answer to this it may be urged, that every point in the arrangement which is acquired immediately becomes permanent and cannot afterwards be subverted, which ought to overbalance a hundred objections.

The consideration of the more minute parts of this scheme will open a new field of enquiry into the secrets of nature, and add to Comparative Anatomy a branch of investigation hitherto little cultivated — the economy of animals respecting their young.

In the outset of this enquiry the landmarks by which I was to be guided in distinguishing animals into their greater divisions, as I have already stated, were the different circumstances under which the molecule is placed, and the different supplies it is to receive before the formation of the embryo is completed. This field affords me a sufficient number of divisions for my classes.

I have since acquired much information which may be

considered of a secondary nature, subordinate to the other; this is the more minute differences in the mode of connection between the mother and the embryo, which affords materials for the greater number of the orders to the classes.

Why two animals of the same genus, as the horse and ass, capable of breeding when allowed to copulate, should produce young whose organs of generation are more or less imperfectly formed, is perhaps what will never be discovered by human sagacity. We know from many circumstances brought forward in this Course of Lectures, that the molecule in the ovum of the female receives some direct impression from the male semen; when therefore the semen of the male of one species is applied to the ovum of the female of another, it may give influence sufficient for the formation of an embryo, but not to render it perfect in its organs of generation, or brain, since we find in hybrid animals both these organs deficient in their energies.

That it is a more difficult process to develope the female organs in a perfect state than any other organs in the body, the brain excepted, is sufficiently proved by what occurs in breeding cattle, as formerly noticed respecting the free-martin.

Although we are unable to explain the cause of two animals producing a young one incapable of propagating, we are now, from having examined into the structure of the placenta, enabled to throw some light on no two animals of different genera breeding together.

The placenta being a part formed after, and in consequence of impregnation, it must partake of both the male and female influence; and as it will be found that every genus has a

placenta whose structure is peculiar to itself, so if a molecule of one genus is impregnated by a male of another genus, a placenta would be required having a structure intermediate between that which belongs to each of the genera, or the embryo could not be what was intended; and as there is no such provision in nature, animals so circumstanced cannot breed together.

The external forms of the placenta of different genera are so unlike, that from their appearance we can readily decide what genus a placenta belongs to.

The appearance of the internal membrane of the uterus in some measure corresponds to that of the surface of the placenta, which it is afterwards to receive; so that, in general, by looking at the internal surface of the uterus, we can decide to what order of animals such uterus belongs, although we cannot venture upon saying to what particular genus of that order.

Upon the structure of the placenta, or chorion, the utero-gestation of the animal must more or less depend. Where the supply of blood-vessels is large, the period will be proportionally short; where it is small, the period will be long.

The human placenta is of the first kind; the period nine months. The mare has no placenta, only a chorion; the period is eleven months. The elephant, whose period is twenty-two months, I have no doubt, from the appearance of the inside of the uterus, has no placenta, but a chorion.

There is a latitude in the utero-gestation of females of the same species: this would appear partly to depend upon the

mother being well or ill nourished; since the wild cow goes longer than cows in general that are domesticated.

The following notices on this subject are published in the Bulletin des Sciences by the Philomatique Society in Paris, for the year 1797, by Mr. Tessier.

Of one hundred and sixty cows some calved in two hundred and forty-one days; five in three hundred and eight, giving a latitude of sixty-seven days. When they go longer than usual it is expected that the calf will be a bull.

In the wild state, the mean period of the cow is said to be three hundred and eight days.

In the gauer, a wild cow discovered in the East Indies, of enormous size, the period is one year.

In the northern parts of America, where Captain Frankland visited the shore of the Arctic ocean, Mr. Richardson, the surgeon, assured me, the wild buffaloes were stated to go one year.

In one hundred and two mares, three foaled in three hundred and eleven days; one in three hundred and ninety-four, — giving a latitude of eighty-three days.

In sows, one in fifteen littered in one hundred and nine days; one in one hundred and twenty-three, — giving a latitude of fourteen days.

In one hundred and thirty-nine rabbits, one produced in twenty-six days; nine in thirty-three,—giving a latitude of seven days.

As the human placenta has a form fitted better than any other for supplying the embryo with blood, there appears to be less liability to latitude than in other animals, at least

in civilized society; it may be otherwise in a savage state, when scantily fed.

When the female of one species has young by the male of another, whose period of utero-gestation is different, there appears to be no approximation in the period of utero-gestation, but the longest period of the two species is that employed.

The she-ass when covered by a horse goes eleven months,—one beyond her usual time.

The mare when covered by an ass, goes eleven months,—her usual period. The Earl of Merton's mare covered by the quagga went three hundred and thirty-nine days nineteen hours.

The direct cause of parturition has never been satisfactorily explained; and the great latitude there is in the utero-gestation in females of the same species, makes it evident that parturition depends upon some circumstance connected with the embryo having arrived at perfection. This leads me to hazard the following observations on this subject:—

The lungs are the last parts of the embryo that are fitted to perform their office. When this happens, the blood circulating through the vessels of the placenta must all at once be very considerably diminished; in consequence of this the small branches of the placenta connected with the uterus will contract, a circumstance which in itself will produce a separation of the placenta from the uterus.

I shall not at present carry these observations farther, but proceed to develope the classification of animals, to which all that has been already stated must be considered as prefatory matter.

In this new arrangement I have placed the human species as a distinct order, separate from all inferior animals, which is undoubtedly the place assigned for man by his Almighty Creator.

The difference that will be pointed out between the human placenta and that of the monkey, shows that there is a principle which must ever prevent a breed taking place between these two orders of animals, and therefore overturns all the idle stories that have been laid before the public upon that subject.

All that can be done in so arduous an undertaking as bringing forward a classification upon a new principle, is, that the principle should be explained, and the outline formed, for others to fill up the more minute parts.

Conclusions drawn from the Experiments on freezing the Brain and Molecule in the Egg, detailed in the fourteenth Lecture.

Upon considering the very important facts established by these experiments, and conceiving them to throw some light upon subjects connected with the mode of classification I am going to bring forward, I shall in this place suggest the following inferences, which in my opinion may be deduced from them.

The fact of the substance of the brain and the molecule in the egg, when completely frozen, and then thawed, dissolving, leads to the belief that the materials of which they are composed are the same.

This explains the similarity of mind of the progeny to that of the parents, also the great resemblance between twins

in both body and mind, instances of which have been given. It accounts for the great variety met with among children of the same parent, the brain undergoing changes in different periods of life, and the materials of which the ova are formed becoming equally changed. It explains insanity running in families.

In birds having the penis of some length, one emission of the male can impregnate eggs in succession for the season. In Norfolk, it is not uncommon to have the turkey hens trod once a year, which is sufficient – in this way the breed of black turkeys is kept up. In the human species and quadrupeds in which the corpus luteum is renewed for every egg, fresh semen is necessary for its impregnation; but as the formation of the corpus luteum and the secretion of the semen are under the excitement of the passions, the influence of the mind upon the ovum can readily be understood, although it may be difficult to the extent in which it occurs; as in the following instance, in addition to those already given of Earl Morton's mare:—A mare of the cart breed was covered by a blood horse, the young was exactly like the father; and when the same mare was covered by a cart-horse, the young resembled that of the blood horse.

That the brain can be frozen, and the spinal marrow be unaffected, in itself implies that they are distinct organs.

That after the brain has been dissolved, the spinal marrow should be capable of carrying on the action of the heart, and, where it has ceased to beat, renew its action, and when that can no longer be done, produce with the aid of galvanism action in the muscles, are facts which place the spinal marrow in a new point of view; and when combined with that

already stated of the number of nerves met with in the growing horn of the deer, lead to the belief of the spinal marrow supplying the nerves to every part of the body for the regulating the action of the arteries, both for the circulation of the blood and producing the secretions; and although closely connected with the brain, yet these actions are not immediately dependant upon it.

I was forcibly struck with this notion by accidentally examining the drawing of the spinal marrow of the tortoise, which I knew had a wonderful power of walking under great weights, and at the two parts where the nerves for the fore and hind legs go off, the spinal marrow is enlarged to double the size of the intermediate portion. In the elephant, the horse, the sheep, and porpoise, there is a neck or narrow part immediately below the going off of the eighth pair, which I consider the origin of the spinal marrow, the corpora pyramidalia and olivaria belonging to the brain. In the monkey, there is the double enlargement, as in the tortoise. In the lion, there is an enlargement in the loins, which probably enables the animal to spring with so much agility. In the ostrich, there is a great enlargement in the loins, all the action being in the legs; and none in the swan. This is noticed by Mr. Hunter, who employs the same reasoning on it that I am now doing. The fawn has the same swell in the loins.

In the first rudiments of the embryo in the chick, the spinal marrow is very small at its origin.

In the torpedo the nerves to the electric organs go off from the brain, the spinal marrow itself being very small.

In the vegetable kingdom the ovula formed in the germen of the flower, corresponding to the molecule on the surface of the yelk, in the yelk-bag, are all impregnated at the same time by the farina of the antheræ, and immediately the embryo begins to form; so that when the seed are shed the embryo is fit to take root, having arrived at the same state of advancement with the chicken when ready to leave the shell of the egg.

The tender ovula are thus protected from the inclemency of the weather, or other accidental injury, till the embryo is placed in security in the seed.

A

SYNOPSIS

OF

THE CLASSES AND ORDERS

OF

THE ANIMAL KINGDOM.

AN

ARRANGEMENT

OF

THE ANIMAL KINGDOM

FOUNDED ON THE MODIFICATIONS OF THE EGG.

Every egg contains a molecule capable of being impregnated, and of forming an embryo.

Out of the different circumstances in which the embryo is developed and becomes a perfect animal, are formed the following twelve classes:

1. Echemetroa. The embryo produced from an egg which is formed in a corpus luteum, developed in the uterus, to which it adheres.

2. Emmetroa. The embryo produced from an egg which is formed either in a corpus luteum or yelk-bag, developed in a uterus, to which it does not adhere.
3. Ecmetroa. The embryo produced from an egg having a yelk and impregnated in a uterus, developed by incubation.
4. Exostoa. The embryo produced from an egg having a yelk and impregnated in the oviduct, developed by incubation.
5. Enaerogenoa. The embryo produced from an egg which is impregnated in the oviduct, developed without incubation.
6. Amphibigenoa. The embryo produced from an egg which is formed in the ovarium, developed in water, having both lungs and external gills!
7. Enhydrogenoa. The embryo produced from an egg which is formed in the ovarium, developed in water, having gills which are covered by an operculum.
8 Metamorphogenoa. The embryo produced from an egg which is formed in the ovarium, subjected to metamorphosis, and breathing by spiracula.

9. Monogenoa. The embryo produced from an egg which is impregnated by a male having only one testicle, breathing by gills.
10. Hermaphroditogenoa. The embryo produced from an egg, the perfect animals hermaphrodite, mutually impregnating one another.
11. Autogenoa. The embryo produced from an egg, the perfect animal hermaphrodite, impregnating itself.
12. Cryptogenoa. Animals, the origin and development of whose embryos are unknown.

CLASSES.

THE NATURAL CHARACTERS OF THE CLASSES.

1*st Class.* ECHEMETROA.

The penis single, enters the female which gives milk.

Heart with two ventricles, and two auricles; blood red, warm.

Lungs, breathing regularly.

Senses: taste, hearing, seeing, smelling, touch.

Covering: hair.

Progressive motion: on four feet.

2d Class. EMMETROA.

The penis bifid, enters the female which gives milk. The nipples contained in a marsupium.

Heart with two ventricles, and two auricles; blood red, warm.

Lungs, breathing regularly.

Senses: taste, smell, seeing, hearing, touch.

Covering: hair.

Progressive motion: on four feet.

3d Class. ECMETROA.

Penis bifid, entering the female which is oviparous.

Heart with two ventricles, and two auricles; blood red, warm.

Lungs, breathing regularly.

Senses: taste, smell, seeing, hearing, touch.

Covering: hair or spines.

Progressive motion: on four feet.

4th Class. EXOSTOA.

Penis not entering, female oviparous.

Heart with two ventricles, and two auricles, blood red, warm.
Lungs, breathing regularly.
Senses: taste, smell, seeing, hearing, touch.
Covering: feathers, lapping over each other.
Progressive motion: feet two, wings two.

5th Class. ENAEROGENOA

Penis double, single, or wanting.
Heart with one ventricle, two auricles, blood red, cold.
Lungs, breathing irregularly.
Senses: taste, smell, seeing, hearing, touch.
Covering: cuticular.
Progressive motion: on feet, on scales.

6th Class. AMPHIBIGENOA

Heart with one ventricle, and one auricle.
Senses: taste, smell, hearing, sight, with or without touch.
Covering: cuticular.
Progressive motion: on feet, four or two.

7th Class. ENHYDROGENOA.

The penis entering the female, or wanting.
Heart with one ventricle, and one auricle; blood red, cold.
Gills.
Senses: taste, hearing, smell, seeing.
Covering: scales, lapping over one another.
Progressive motion: with fins.

8th Class. METAMORPHOGENOA.

The penis entering the female.
Heart wanting; blood white.
Breathing, performed by lateral spiracula.
Senses: taste, smell, seeing, hearing, and touch by antennæ.
Covering: horn generally.
Progressive motion: feet, sometimes wings.

9th Class. MONOGENOA.

The penis entering the female, or wanting.
Heart with one or two ventricles, one or two auricles.
Gills.

Senses: hearing, touch by antennæ or tentacula, with or without sight.

Covering: cuticular, or shell.

Progressive motion: by a cartilaginous foot or tentacula.

10*th Class.* HERMAPHRODITOGENOA.

The penis entering the female.

Heart with one ventricle.

Lungs.

Senses: touch, with or without sight.

Covering: cuticular, or shell.

Progressive motion: on a cartilaginous foot

11*th Class.* AUTOGENOA.

Heart with one ventricle, and one or two auricles.

Gills.

Senses: smell, seeing, hearing.

Covering: various.

Progressive motion: with fins.

12*th Class.* CRYPTOGENOA.

The ovum not yet discovered.

The internal organs various, and in some indistinct.

Class 1st. ECHEMETROA.

CHARACTERS OF THE ORDERS TAKEN FROM THE STRUCTURE OF THE PLACENTA.

Order 1. Placenta lobulated on the uterine surface only.
2. divided into two portions by a venal canal.
3. surrounding the embryo like a belt.
4. completely divided into lobes.
5. in form of a cup.
6. Placentas, many, in form of cups (cotyledons).
7. Chorion having no placenta.

Order 1. Placenta lobulated on the uterine surface only.

The breasts pectoral, two, hemispherical, without hair.

The body without hair, erect, hair on the head.
The face without hair, the male having a beard.
In walking, tread on the heel.
Have clavicles.
Without a tail.

Order 2. Placenta divided into two portions by a venal canal.

The breasts pectoral, two covered with hair.
The body covered with hair.
Use all four feet as hands, the nails smooth.
Have clavicles.
Walk commonly on all fours.
Having a tail, or the rudiments of one.

Order 3. Placenta surrounding the embryo like a belt.

The organ of hearing distressed by deep and loud sounds.
Walk with the toe-nails retracted.

Order 4. Placenta completely divided into lobes.

The feet covered with hair, the anterior much the shortest.
Having numerous progeny.

Order 5. Placenta in form of a cup.

The genera of this order differ exceedingly in their form and habits.

Order 6. Placentas, many, in form of cups (cotyledons).

Having horns, which are solid, and deciduous, or concave and permanent.

Order 7. Chorion having no placenta.

The males having tusks.

Fight with the teeth, and by kicking with the hind feet.

Class 2d. EMMETROA.

CHARACTERS OF THE ORDERS FROM STRUCTURE OF THE OVUM.

Order 1. Ovum in a corpus luteum.
2. in a yelk-bag.

Order 1. Ovum in a corpus luteum.

The breasts that give milk are contained in a marsupium.

Order 2. Ovum in a yelk-bag.

The breasts in a marsupium.

Class 3d. Echmetroa.

CHARACTER OF THE ORDERS FROM THE STRUCTURE OF THE PENIS.

Order 1. The penis double, only seminiferous; apertures nine.
2. The penis double, only seminiferous; apertures four.

Order 1. The penis double, only seminiferous; apertures nine.

Mouth like a duck.
Hair resembling feathers.

Order 2. The penis double, only seminiferous; apertures four.

The tongue of extreme length.
Covered with hair and quills.

Class 4th. Exostoa

CHARACTERS OF ORDERS FROM THE NESTS OF THE EGGS.

Order 1. A simple nest loosely constructed of rough twigs and small branches, without an interior lining.

2. A hollow nest made of grasses and tender branches, loosely constructed; the inner part softer.

3. A nest constructed of tender twigs; the inside close and soft, the outer compact.

4. A nest made of softer materials, loosely put together.

5. A nest constructed with great art, and suspended; of an oval figure.

Order 6. Two eggs deposited on the earth, surrounded loosely by fragments of wood.

7. Many eggs deposited on the earth, in a hemispherical nest.

8. A few eggs deposited on the ground, in damp situations.

9. Eggs deposited on the ground, in lofty situations.

10. Eggs deposited on the sea-shore or borders of lakes, without nests.

11. Eggs deposited in nests on the banks of fresh-water lakes.

12. A solitary egg deposited on rocks in the sea.

Order 1. A simple nest loosely constructed of rough twigs and small branches, without an interior lining.

Eggs generally four.
Feet fitted for standing; legs short, robust.
Claws arched, very acute.

Order 2. Nest hollow, made of grasses and tender branches, loosely constructed; the inner part softer.

Beak cutting at the edge, the back convex.
Frontlet reversed.
Feet fitted for walking, stout.

Order 3. Nest constructed of tender twigs; the inside close and soft, the outer compact.

The beak: the upper mandible a little bending, notched near the point; compressed at the base.
The feet fitted for leaping; slender, divided.

Order 4. Nest made of softer materials, loosely put together.

The beak a little bending.
The tongue fissured.
The posterior claw small.

Order 5. Nest constructed with great art, and suspended; of an oval figure.

The beak conical, acute.

Order 6. Two eggs deposited on the earth, surrounded loosely by fragments of wood.

The beak a little arched.

Forms a species of secretion in the crop, for the nourishment of the young.

Order 7. Many eggs deposited on the earth, in a hemispherical nest.

The beak convex, the superior mandible arched over the under.

Feet for walking.

Food, grains macerated in the crop.

Order 8. A few eggs deposited on the ground, in damp situations.

Feet for wading.

Food, the smaller animals of marshy grounds.

Order 9. Eggs deposited on the ground, in lofty situations.

Beak subcylindric, straight, sharp.

Order 10. Eggs deposited on the sea-shore or borders of lakes, without nests.

Beak covered with a thin cuticle, sharp at the point.

Feet webbed, for swimming.

Order 11. Eggs deposited in nests on the banks of fresh-water lakes.

Beak terminating in a hook, with denticulated membranous edges.

Order 12. A solitary egg deposited on rocks in the sea.

The beak bent, sides slightly compressed.

Teeth in fauces.

Feet webbed.

Class 5th. ENAEROGENOA.

CHARACTERS OF THE ORDERS, FROM PECULIARITIES IN THE PENIS.

Order 1. The penis single, entering the female.
2. The penis double, entering the female.
3. The penis wanting.

Order 1. The penis single, entering the female.

Tenacious of life, the action of the heart kept up after the removal of the brain by the spinal marrow.

Having four feet.

Having a tail.

Covering: cuticle, shell, or otherwise.

Order 2. The penis double, entering the female.

Without feet.
Covering: scales, rings, or rugæ.

Order 3. Penis wanting.

Tail wanting.
Eggs in spawn.
Young with gills, (tadpoles).
The perfect animal with lungs

Class 6th. AMPHIBIGENOA.

THE CHARACTERS OF THE ORDERS FROM THE FEET.

Order 1. The fore feet with three toes, hind with two.

2. The fore feet with four toes, hind with five.

3. The fore feet with three toes: no hind feet.

Order 1. The fore feet with three toes, hind with two.

Anguiform.
Carniverous.
Habitation: subterraneous caverns in Germany.

Order 2. The fore feet with four toes, hind with five.

Form common to lizards.
Habitation: the lakes of Mexico.

Order 3. The fore feet with three toes: the hind wanting.

Anguiform.
Habitation: the lakes of Carolina.

Class 7th. Enhydrogenoa.

THE CHARACTERS OF THE ORDERS FROM THE SITUATIONS IN WHICH THE OVA ARE HATCHED.

Order 1. The embryo developed from the egg in the oviduct or floating in the sea.

2. The embryo developed from the egg near the spring heads of rivers.

3. The embryo developed from the egg upon fresh-water grasses.

4. The embryo developed from the egg upon weeds at the water's edge in rivers.

5. The embryo developed from the egg in shallows in the sea.

6. The embryo developed from the egg on sand banks in the sea.

7. The embryo developed from the egg at the bottom of the sea.

8. The embryo developed from the egg in the sand of the sea-shore.

Order 1. The embryo developed from the egg in the oviduct or floating in the sea.

Spiracula, either lateral or below, five in number.

Order 2. The embryo developed from the egg near the spring heads of rivers.

The branchial membranes four rays or ten.

Order 3. The embryo developed from the egg upon fresh-water grasses.

The branchial membranes three rays.

Order 4. The embryo developed from the egg upon weeds at the water's edge in rivers.

The inferior jaw longer than the upper.
Voracious.
Indiscriminate in its food.

Order 5. The embryo developed from the egg in shallows in the sea.

The abdomen carinated, serrated.

Order 6. The embryo developed from the egg on sand banks in the sea.

Both eyes on the left side.

Order 7. The embryo developed from the egg at the bottom of the sea.

Branchial membranes three rays.
The scales on the head loose.

Order 8. The embryo developed from the egg in the sand of the sea-shore.

Branchial membranes seven.

Class 8th. Metamorphogenoa.

CHARACTERS OF THE ORDERS FROM THE SITUATIONS IN WHICH THE OVA ARE DEPOSITED.

Order 1. The embryo developed from eggs attached under the tail.

2. The embryo developed from eggs carried upon the anterior feet.
3. The embryo developed from eggs deposited under the cuticle of the skin or stomach.
4. Embryos developed from eggs for several generations, impregnated at the same time by one male.
5. Embryos produced from eggs of one mother, that compose the whole republic.
6. Embryos from eggs deposited under water.

Order 1. The embryo developed from eggs attached under the tail.

Feet eight.
Eyes distant, moveable.
The horny stomach annually shed.

Order 2. The embryo developed from eggs carried upon the anterior feet.

Eyes eight.
Feet eight.

Order 3. The embryo developed from eggs deposited under the cuticle of the skin, or stomach.

With three orifices, but no proboscis.
Mouth imperfect.
Two wings.
Feelers clavated, solitary behind each wing under a proper scale.

Order 4. Embryos developed from eggs for several generations, impregnated at the same time by one male.

The rostrum inflexible.
The antennæ longer than the thorax.

Order 5. Embryos produced from eggs of one mother, that compose the whole republic.

The tongue inflexible.
The sting sharp, that of female and neuters having the point concealed.

Order 6. Embryos from eggs deposited under water.

The tail simple.
The mouth without teeth.
Wings bent down.

Class 9th. Monogenoa.

THE CHARACTERS OF THE ORDERS FROM THE CONNECTIONS BETWEEN THE OVA.

Order 1. The embryo developed from eggs connected together by fibres like grapes.

2. The embryo developed from eggs enclosed in connected cells attached at the bottom of the sea.

3. The embryo developed from eggs in connected cells deposited on their shells.

Order 1. The embryo developed from eggs connected together by fibres like grapes.

Eight or ten arms studded with cup like suckers.
The mouth in the middle, beak horny.

Order 2. The embryo developed from eggs enclosed in connected cells attached at the bottom of the sea.

The animal a molusque.
The shell univalve.

Order 3. The embryo developed from eggs in connected cells deposited on the shells of the parent.

The animal a molusque.
Shell univalve, spiral, almost transparent

Class 10th. HERMAPHRODITOGENOA.

THE CHARACTERS OF THE ORDERS TAKEN FROM THE ORGANS OF GENERATION.

Order 1. Two individuals reciprocally impregnating each other.

2. Four individuals, or more, connected in a chain or circle, impregnating each other.

Order 1. Two individuals reciprocally impregnating each other.

The animal a molusque.
The shell a univalve.
The eggs deposited and hatched in the earth.
The anus and organs of generation having the same lateral orifice.

Order 2. Four individuals, or more, connected in a chain or circle, impregnating each other.

The animal a molusque.
The anus and penis having distinct lateral orifices.
The ova deposited in the sea, in form of spawn.

Class 11th. AUTOGENOA.

THE CHARACTERS OF THE ORDERS FROM THE FORM AND COVERING OF THE ANIMAL.

Order 1. Form fish-like, naked.
2. Form cylindrical, shell tubular.
3. Animal inclosed in a bivalve.
4. Form star-like.

Order 1. Form fish-like, naked.

Mouth round; paved with teeth.
Body cylindrical.
Heart, and circulation of blood as in fishes.

Order 2. Form cylindrical, shell tubular.

Mouth having two perforating valves.
Stomach divided into two portions.

Order 3. The animal inclosed in a bivalve.

The organs of generation not known.
The heart, one cavity.

Order 4. Form star-like.

The mouth central.
The organs of generation not ascertained.
The heart wanting.

Class 12th. CRYPTOGENOA.

THE CHARACTERS OF THE ORDERS FROM THE SUBSTANCE OF WHICH THE ANIMAL IS COMPOSED.

Order 1. The animal membranaceous, without organs.

2. The animal gelatinous, with organs.
3. The animals aggregated in a branched form, with a horny external coat.
4. The animals aggregated in a branched form, with an internal, stony, or horny stem.

Order 1. The animal membranaceous: without organs.

Form globular.

Order 2. Animal gelatinous: with organs.

Has an external mouth, which is central.
Various tentacula, or none.

Order 3. Animals aggregated in a branched form, with horny external coat.

External form like a tree.

Order 4. The animals aggregated in a branched form, with an internal horny or stony stem.

From the ramification of the stem the genera are arranged.

EXAMPLES OF GENERA

OF EACH OF THE PRECEDING ORDERS

Class 1st. ECHEMETROA.

GENERA.

Order 1. Placenta lobulated on the uterine surface only.

1. Man.

Order 2. Placenta divided into two portions by a venal canal.

2. Monkey.

Order 3. Placenta surrounding the embryo like a belt.

3. The belt broad. Lion.
4. The belt narrow. Dog.

GENERA.

Order 4. Placenta completely divided into lobes.

5. The lobes five. Hare.

Order 5. Placenta in form of a cup.

6. The cup simple. Porcupine.
7. The cup smooth. Mole.
8. The cup thick. Bat.
9. The cup with a foot. Mouse.
10. The cup with a small foot. Rat.

Order 6. Placentas, many, in form of cups (cotyledons).

11. Terminal arteries ramifying. Ox.
12. Terminal arteries in form of thread. Deer.
13. Terminal arteries in villi. Sheep.
14. Terminal arteries in tufts. Goat.

GENERA.

Order 7. Chorion having no placenta.

15. The structure thick. Horse.
16. The structure tufted. Whale.
17. The structure stellated. Hog.
18. Structure minutely vascular. Camel.
19. Structure not known. Elephant.

Class 2d. Emmetroa.

Genera.

Order 1. Ovum in a corpus luteum.

20. The Kanguroo.
21. The Kanguroo rat.
22. The austral Opossum with a prehensile tail.
23. The austral flying Opossum.

Order 2. Ovum in a yelk-bag.

24. Koala.
25. The American Opossum.

Class 3d. ECMETROA.

GENERA.

Order 1. The penis double, only seminiferous; apertures nine.

26. Ornithorhyncus paradoxus.

Order 2. The penis double, only seminiferous; apertures four.

27. Ornithorhyncus hystrix.

Class 4th. Exostoa.

Genera.

Order 1. A simple nest loosely constructed of rough twigs and small branches, without an interior lining.

28. Falcon.

Order 2. A hollow nest made of grasses and tender branches, loosely constructed; the inner part softer.

29. Crow.

Order 3. A nest constructed of tender twigs; the inside close and soft, the outer compact.

30. Thrush.

GENERA.

Order 4. A nest made of softer materials, loosely put together.

31. Warbler.

Order 5. A nest constructed with great art, and suspended; of an oval figure.

32. Finch.

Order 6. Two eggs deposited on the earth, surrounded loosely by fragments of wood.

33. Pigeon.

Order 7. Many eggs deposited on the earth, in a hemispherical nest.

34. Pheasant.

Order 8. A few eggs deposited on the ground, in damp situations.

35. Lapwing.

GENERA.

Order 9. Eggs deposited on the ground, in lofty situations.

36. Crane.

Order 10. Eggs deposited on the sea-shore or borders of lakes, without nests.

37. Gull.

Order 11. Eggs deposited in nests on the banks of fresh-water lakes.

38. Goose.

Order 12. A solitary egg deposited on rocks in the sea.

39. Guillemot.

Class 5th. ENAEROGENOA.

GENERA.

Order 1. The penis single, entering the female.

40. Lizards.

Order 2. The penis double, entering the female.

41. Snakes.

Order 3. The penis wanting.

42. Frogs.

Class 6th. AMPHIBIGENOA.

GENERA.

Order 1. The fore feet with three toes, hind with two.

43. German Proteus.

Order 2. The fore feet with four toes, hind with five.

44. Mexican Proteus.

Order 3. The fore feet with three toes: no hind feet.

45. South American Proteus.

Class 7th. ENHYDROGENOA.

GENERA.

Order 1. The embryo developed from the egg in the oviduct or floating in the sea.

46. Shark.

Order 2. The embryo developed from the egg near the spring heads of rivers.

47. Salmon.

Order 3. The embryo developed from the egg upon fresh-water grasses.

48. Tench.

GENERA.

Order 4. The embryo developed from the egg upon weeds at the water's edge in rivers.

49. Pike.

Order 5. The embryo developed from the egg in shallows in the sea.

50. Pilchard.

Order 6. The embryo developed from the egg on sand-banks in the sea.

51. Turbot.

Order 7. The embryo developed from the egg at the bottom of the sea.

52. Mullet.

Order 8. The embryo developed from the egg in the sand of the sea-shore.

53. Cod.

Class 8th. METAMORPHOGENOA.

GENERA.

Order 1. The embryo developed from eggs attached under the tail.

54. Lobsters.

Order 2. The embryo developed from eggs carried upon the anterior feet.

55. Spiders.

Order 3. The embryo developed from eggs deposited under the cuticle of the skin or stomach.

56. Gad fly.

GENERA.

Order 4. Embryos developed from eggs for several generations, impregnated at the same time by one male.

57. Plant louse.

Order 5. Embryos produced from eggs of one mother, that compose the whole republic.

58. Bees.

Order 6. Embryos from eggs deposited under water.

59. Water moth.

Class 9th: MONOGENOA.

GENERA.

Order 1. The embryo developed from eggs connected together by fibres like grapes.

60. Cuttle fish.

Order 2. The embryo developed from eggs enclosed in connected cells attached at the bottom of the sea.

61. Chank.

Order 3. The embryo developed from eggs in connected cells deposited on their shells.

62. Sea snail (Janthena).

Class 10th. Hermaphroditogenoa.

Genera.

Order 1. Two individuals reciprocally impregnating each other.

63. Garden snail.
64. Earth worm.

Order 2. Four individuals, or more, connected in a chain or circle, impregnating each other.

65. Bulin.
66. Caret (Adinson).

Class 11th. Autogenoa.

Genera.

Order 1. Form fish-like, naked.

67. Conger eel.
68. Lamprey.

Order 2. Form cylindrical, shell tubular.

69. Worms that destroy ships' bottoms.

Order 3. Animal inclosed in a bivalve

70. Oyster.

Order 4. Form star-like.

71. Star fish.

Class 12th. CRYPTOGENOA.

GENERA.

Order 1. The animal membranaceous, without organs.

72. Hydatids.

Order 2. The animal gelatinous, with organs.

73. Sea blubber.

Order 3. The animals aggregated in a branched form, with a horny external coat.

74. Sea fans.

GENERA.

Order 4. The animals aggregated in a branched form, with an internal, stony, or horny stem.

75. Branching coral.

SYNOPSIS

SYSTEMATIS REGNI ANIMALIS.

SYSTEMA

REGNI ANIMALIS,

NUNC PRIMUM EX OVI MODIFICATIONIBUS PROPOSITUM.

CLASSES.

1. Echemetroa. Embryo ex ovo in corpore luteo formato, evolutus in utero quocum adhæret.
2. Emmetroa. Embryo ex ovo vel in corpore luteo vel in vitello formato, evolutus in utero a quo solutus.
3. Ecmetroa. Embryo ex ovo vitello instructo et in utero impregnato, incubatione evolutus.

4. Exostoa. Embryo ex ovo vitello instructo et in oviducto impregnato, incubatione evolutus.
5. Enaerogenoa. Embryo ex ovo in oviducto impregnato, absque incubatione evolutus.
6. Amphibigenoa. Embryo ex ovo in ovario formato, instructus pulmonibus, et branchiis nudis, evolutus in aqua
7. Enhydrogenoa. Embryo ex ovo in ovario formato, branchiis operculo tectis instructus, evolutus in aqua.
8. Metamorphogenoa. Embryo ex ovo in ovario formato, subjectus metamorphosi, stigmatibus respirens.
9. Monogenoa. Embryo ex ovo a mare monorchide impregnato, branchiis instructus.
10. Hermaphroditogenoa. Embryo ex ovo hermaphroditi duplicis.
11. Autogenoa. Embryo ex ovo hermaphroditi unici.
12 Cryptogenoa. Embryones, quorum primordia ignota.

CLASSIUM CHARACTERES NATURALES.

1. Echemetroa.

Penis simplex, intrans lactiferas.
Cor biloculare, biauritum; sanguine calido, rubro.
Pulmones reciproce respirantes.
Sensus: lingua, nares, oculi, aures, papillæ.
Tegmenta: pili.
Fulcra: pedes quatuor.

2. Emmetroa,

Penis bifidus, intrans lactiferas marsupio instructas.
Cor biloculare, biauritum; sanguine calido, rubro.
Pulmones reciproce respirantes.

Sensus: lingua, nares, oculi, aures, papillæ.
Tegmenta: pili.
Fulcra: pedes quatuor.

3. Ecmetroa.

Penis bifidus, intrans oviperas.
Cor biloculare, biauritum; sanguine calido, rubro.
Pulmones reciproce respirantes.
Sensus: lingua, nares, oculi, aures, papillæ.
Tegmenta: pili, sive spinæ.
Fulcra: pedes quatuor.

4. Exostoa.

Penis subintrans oviperas.
Cor biloculare, biauritum; sanguine calido, rubro.
Pulmones reciproce respirantes.
Sensus: lingua, nares, oculi, aures, papillæ.
Tegmenta: pennæ incumbentes, imbricatæ.
Fulcra: pedes bini; alæ binæ.

5. Enaerogenoa.

Penis unicus, vel duplex, vel nullus.
Cor uniloculare, biauritum, sanguine frigido, rubro.
Pulmones arbitrie respirantes.
Sensus: lingua, nares, oculi, aures, papillæ.
Tegmenta cutacea.
Fulcra varia in variis, in quibusdam nulla.

6. Amphibigenoa.

Cor uniloculare, uniauritum.
Sensus: lingua, nares, aures, papillæ, sæpius absque oculis.
Tegmenta cutacea.
Fulcra: pedes bini vel quatuor.

7. Enhydrogenoa.

Penis intrans, aut nullus.
Cor uniloculare, uniauritum; sanguine frigido, rubro.
Branchiæ.
Sensus: lingua, nares, oculi, aures.
Tegmenta: squamæ imbricatæ.
Fulcra: pinnæ.

8. METAMORPHOGENOA.

Penis intrans.
Cor nullum.
Sanguis albus.
Spiracula: pori laterales.
Sensus: lingua, nares, oculi, aures, antennæ.
Tegmenta cataphracta.
Fulcra: pedes, quibusdam alæ.

9. MONOGENOA.

Penis intrans, aut nullus.
Cor uni-biloculare, uni-biauritum.
Branchiæ.
Sensus: aures, antennæ, tentacula, oculi, quibusdam nulli.
Tegmenta vel cutacea, vel testacea.
Fulcra: pes cartilagineus, tentacula.

10. HERMAPHRODITOGENOA.

Penis intrans.
Cor uniloculare, uniauritum.
Pulmones.
Sensus: tentacula, oculi quibusdam.
Tegmenta vel cutacea, vel testacea.
Fulcra: pes cartilagineus.

11. Autogenoa.

Cor uniloculare; uni-bi-auritum.
Branchiæ.
Sensus: plerisque nares, oculi, aures, lingua, quibusdam tactus solum.
Tegmenta: varia.
Fulcra: pinnæ, vel nulla.

12. Cryptogenoa.

Ovum nondum observatum.
Organa interna varia, nunc indistincta.

ECHEMETROA.

CHARACTERES ORDINUM E PLACENTÆ STRUCTURA DESUMPTÆ.

Ordo 1. Placenta indivisa.
2. canali vasculari bipartita, explanata.
3. embryonem circumdans cinguli instar, indivisa.
4. multifida, explanata.
5. calyciformis, unica.
6. Placentæ calyciformes, numerosæ (cotyledones).
7. Chorion sine placenta.

Ordo 1. Placenta indivisa.

Mammæ pectorales, duæ, hemisphæricæ, nudæ.

Corpus erectum, nudum: caput pilosum.

Facies maribus barbata.

Pedes talis insistentes.

Claviculæ.

Cauda nulla.

Ordo 2. Placenta canali vasculari bipartita, explanata.

Mammæ pectorales, binæ, hirsutæ.

Corpus pilis tectum.

Quadrumana: ungues complanati ovales.

Claviculæ.

Incessu tetrapede.

Cauda, nunc abbreviata.

Ordo 3. Placenta indivisa embryonem circumdans cinguli instar, indivisa.

Unguibus retractis incedit.

Sonitum tubæ stentoriæ agrè fert.

Ordo 4. Placenta multifida, explanata.

Pedes lanati; anteriores multo breviores.
Numerosus parturitione.

Ordo 5. Placenta calyciformis, unica.

Genera hujus ordinis structura moribusque admodum varia:

Ordo 6. Placentæ calyciformes, numerosæ (cotyledones).

Cornua vel solida decidua, vel concava persistentia.

Ordo 7. Chorion sine placenta.

Dentes laniarii elongati.
Dentibus et calcitando pugnant.

Emmetroa.

CHARACTERES ORDINUM EX OVI STRUCTURA.

Ordo 1. Ovum absque vitello, corpore luteo formatum.
2. Ovum vitello instructum.

ECMETROA.

CHARACTERES ORDINUM E STRUCTURA PENIS.

Ordo 1. Penis bifidus, aperturis novem.
2. Penis bifidus, aperturis quatuor.

Ordo 1. Penis bifidus, aperturis novem.
Pili plumacei.
Os anatinum.

Ordo 2. Penis bifidus, aperturis quatuor.
Tectus pilis et spinis.
Lingua elongata.

Exostoa.

CHARACTERES ORDINUM E STRUCTURA NIDI.

Ordo 1. Nidus planus, rudis ex ramulis virgisque, sine involucro interiore, laxe constructus.

2. Nidus concavus, ramunculis graminibusque laxe constructus, involucro interiore.

3. Nidus virgulis tenuioribus arcte constructus, involucro interiore molli.

4. Nidus tenuior, laxe constructus, involucro interiore.

5. Nidus pendulus subsphæricus, miranda solertia contextus.

6. Ova bina super terram deposita, ligni fragmentis laxe cincta.

7. Ova numerosa nido hemisphærico, super terram deposito.

Ordo 8. Ova perpauca, locis humidis deposita.
9. Ova deposita locis excelsis.
10. Ova absque nido, prope maris lacuumque litora deposita.
11. Ova nido deposita ad lacuum insalsorum margines.
12. Ovum solitarium in rupibus maris depositum.

Ordo 1. Nidus planus rudis ex ramulis virgisque, sine involucro interiore, laxe constructus.

Ova circiter quatuor.
Pedes insidentes, breves robusti, unguibus arcuatis acutissimis.

Ordo 2. Nidus concavus ramunculis graminibusque laxe constructus, involucro interiore.

Rostrum cultratum dorso convexo: capistro reverso.
Pedes ambulantes, validiusculi.

Ordo 3. Nidus virgulis tenuioribus arcte constructus, involucro molli interiore.

Rostrum emarginatum, subulatum basi compressum.
Pedes salientes, teneri, fissi.

Ordo 4. Nidus tenuior laxe constructus, involucro interiore.

Rostrum subulatum.
Lingua incisa.
Unguis posticus modicus.

Ordo 5. Nidus pendulus subsphæricus, miranda solertia contextus.

Rostrum conicum acutum.

Ordo 6. Ova bina, super terram deposita, ligni fragmentis laxe cincta.

Rostrum subfornicatum.
Pulli secretione ingluviei nutriti.

Ordo 7. Ova numerosa, nido hemisphærico, super terram deposito.

Rostrum convexum, mandibula superiore fornicata supra inferiorem.

Pedes cursorii.

Victus e granis in ingluvie macerandis.

Ordo 8. Ova perpauca, locis humidis deposita.

Pedes vadantes.

Victus in paludibus ex animalculis.

Ordo 9. Ova deposita locis excelsis.

Rostrum subcylindricum, rectum, acutiusculum.

Ordo 10. Ova absque nido prope maris lacuumque litora deposita.

Rostrum læve epidermide tectum, apice acutum.

Pedes natatorii, digitis membrana palmatis.

Ordo 11. Ova nido deposita ad lacuum insalsorum margines.

Rostrum unguiculatum denticulis membranaceis.

Ordo 12. Ovum solitarium maris in rupibus depositum.

Rostrum subulatum lateribus compressiusculum.

Faux dentata.

Pedes compedes.

Enaerogenoa.

ORDINUM CHARACTERES E PENIS STRUCTURA.

Ordo 1. Penis intrans simplex.
2. Penis intrans duplex.
3. Penis nullus.

Ordo 1. Penis intrans simplex.

Vitæ tenacia.
Pedata.
Caudata.
Tegmenta: cutacea, testacea.

Ordo 2. Penis intrans duplex.

Apoda.
Tegmenta: scuta vel squamæ.

Ordo 3. Penis nullus.

Acaudata.

Ova gelatine in massam coacervata.

Respiratio embryonis cum branchiis, animalis evoluti pulmonibus.

Amphibigenoa.

ORDINUM CHARACTERES E PEDIBUS.

Ordo 1. Pedes antici tridactyli, postici didactyli.
2 Pedes antici tetradactyli, postici pentadactyli.
3. Pedes antici tridactyli, postici nulli.

Ordo 1. Pedes antici tridactyli, postici didactyli.

Corpus anguiforme.
Carnivorum.

Ordo 2. Pedes antici tetradactyli, postici pentadactyli.

Corpus lacertæforme.

Ordo 3. Pedes antici tridactyli, postici nulli.

Corpus anguiforme.

ENHYDROGENOA.

ORDINUM CHARACTERES EX EMBRYONIS MODIS EVOLUTIONIS.

Ordo 1. Embryo ex ovo vel in oviducto vel in mare libero evolutus.

2. Embryo ex ovo prope ortum fluviorum deposito evolutus.

3. Embryo ex ovo in graminibus aquaticis deposito evolutus.

4. Embryo ex ovo in plantis ad margines fluviorum deposito evolutus.

5. Embryo ex ovo in mare vadoso deposito evolutus.

6. Embryo ex ovo in pulvinis arenosis maris deposito evolutus.

7. Embryo ex ovo in mare profundo deposito evolutus.

8. Embryo ex ovo in arenis maritimis deposito evolutus.

Ordo 1. Embryo ex ovo vel in oviducto vel in mare libero evolutus.

Spiracula subtus vel lateralia.

Ordo 2. Embryo ex ovo prope ortum fluviorum, deposito evolutus.

Membrana branchialis radiis quatuorvel decem.

Ordo 3. Embryo ex ovo in graminibus aquaticis deposito evolutus.

Membrana branchialis radiis tribus.

Ordo 4. Embryo ex ovo in plantis ad margines fluviorum deposito evolutus.

Mandibula inferior longior.
Omnivora.

Ordo 5. Embryo ex ovo in mare vadoso deposito evolutus.

Abdomen carinatum serratum.

Ordo 6. Embryo ex ovo in pulvinis arenosis maris deposito evolutus

Oculi sinistri.

Ordo 7. Embryo ex ovo in mare profundo deposito evolutus.

Membrana branchialis radiis tribus.
Squamæ capitis laxæ.

Ordo 8. Embryo ex ovo in arena maritima deposito evolutus.

Membrana branchialis radiis septem.

Metamorphogenoa.

ORDINUM CHARACTERES EX OVORUM NIDIS.

Ordo 1. Embryo ex ovis caudæ affixis.

2. Embryo ex ovis pedibus anterioribus affixis.
3. Embryo ex ovis sub epidermide cutis vel ventriculi depositis.
4. Embryones ex ovis plurium generationum unico mare impregnatis.
5. Mater unica rempublicam producens.
6. Embryones ex ovis in aqua depositis.

Ordo 1. Embryo ex ovis caudæ affixis.

Pedes octo.
Oculi distantes mobiles.
Ventriculus quotannis renovatus.

Ordo 2. Embryo ex ovis pedibus anterioribus affixis.

Oculi sæpius octo.
Pedes octo.

Ordo 3. Embryo ex ovis sub epidermide cutis vel ventriculi depositis.

Os clausum seu nullum : tubercula tria absque proboscide.
Alæ duæ.
Halteres clavati, solitarii pone singulam alam, sub squamula propria.

Ordo 4. Embryones ex ovis plurium generationum unico mare impregnatis.

Rostrum inflexum.
Antennæ thorace longiores.

Ordo 5. Mater unica rempublicam producens.

Lingua inflexa.

Aculeus feminis et neutris punctorius reconditus.

Ordo 6. Embryones ex ovis in aqua depositis.

Cauda simplex.

Os edentulum.

Alæ deflexæ.

Monogenoa.

ORDINUM CHARACTERES AB OVORUM CONNEXU.

Ordo 1. Ova racematim connexa.
2. Ova in cameris membranaceis imo maris affixa.
3. Ova in cameris membranaceis cochlea parentis deposita.

Ordo 1. Ova racematim connexa.

Brachia octo vel decem interius adspersa cotyledonibus.

Os inter brachia terminale corneum.

Ordo 2. Ova in cameris membranaceis imo maris affixa.

Animalia mollusca.

Testa univalvis, crassa, opaca.

Ordo 3. Ova in cameris membranaceis cochlea parentis deposita.

Animalia mollusca.

Testa univalvis, spiralis subdiaphana.

Hermaphroditogenoa.

ORDINUM CHARACTERES DE MODIFICATIONIBUS ORGANORUM GENITALIUM.

Ordo 1. Individua duo mutuo sese impregnantia.
2. Individua quatuor aut plura in circulum connexa se invicem impregnantia.

Ordo 1. Individua duo mutuo sese impregnantia.

Animalia mollusca concha tecta.
Ova in terra deposita et evoluta.
Anus communis cum poro laterali.

Ordo 2. Individua quatuor aut plura in circulum connexa, se invicem impregnantia.

Animalia mollusca.
Pori laterales duo.
Ova gelatine glutinosa coacervatim tecta, in aqua deposita.

AUTOGENOA.

ORDINUM CHARACTERES DE ANIMALIUM FORMA.

Ordo 1. Piscerina.
2. Tubularia calcaria.
3. Animalia testa bivalvi.
4. Asteroidea.

Ordo 1. Piscerina.

Os orbiculare dentibus instructum.
Corpus teretiusculum.
Cor uniloculare uniauritum, sanguine rubro.

Ordo 2. Tubularia calcaria.

Os instructum valvulis duabus perforantibus.
Ventriculus bipartitus.

Ordo 3. Animalia testa bivalvi.

Generationis organa nondum detecta.
Cor uniloculare

Ordo 4. Asteroidea.

Os centrale.
Organa generationis non satis cognita.
Cor nullum.

Cryptogenoa.

ORDINUM CHARACTERES DE ANIMALIUM STRUCTURA.

Ordo 1. Animal membranaceum absque organis internis.

2. Animal gelatinosum, organis internis manifestis.

3. Animalia sæpius aggregata, forma determinata, stirpe externa cornea.

4. Animalia sæpius aggregata, forma determinata, stirpe interna cornea vel lapidea.

Ordo 1. Animal membranaceum absque organis internis.

Forma globosa.

Ordo 2. Animal gelatinosum organis internis manifestis.

Os subtus centrale.
Tentacula varia aut nulla.

Ordo 3. Animalia sæpius aggregata, forma determinata, stirpe externa, cornea.

Ramificatio stirpis varia sæpe fructiciformis.

Ordo 4. Animalia sæpius aggregata, forma determinata, stirpe interna, cornea vel lapidea.

Ramificatio stirpis in variis varia.

EXEMPLA GENERUM

SINGULORUM ORDINUM.

ECHEMETROA.

GENERA.

Ordo 1. Placenta indivisa.

1. Homo.

Ordo 2. Placenta canali vasculari bipartita, explanata.

2. Simia.

Ordo 3. Placenta indivisa embryonem circumdans cinguli instar.

3. Leo. Placentæ fascia lata.
4. Canis. Placentæ fascia angusta.

Ordo 4. Placenta explanata multifida.

5. Lepus. Placenta quinquifida.

GENERA.

Ordo 5. Placenta calyciformis unica.

6. Hystrix. Placenta sessilis calyciformis simplex.
7. Talpa. Placenta sessilis scutelliformis plana.
8. Vespertilio. Placenta sessilis calyciformis, basi incrassatà hemisphæricâ.
9. Mus. Placenta pedunculata.

Ordo 6. Placentæ calyciformes numerosæ (cotyledones).

10. Bos. Placentæ arteriæ terminales ramosæ.
11. Cervus. — indivisæ filiformes.
12. Ovis. villosæ.
13. Capra. pilosæ.

Ordo 7. Chorion sine placenta.

14. Equus. Chorion crassum læve.
15. Balæna. cristatum.
16. Sus. stellatim vasculare.
17. Camelus. absque ordine vasculare.
18. Elephas. non satis notum.

EMMETROA.

GENERA.

Ordo 1. Ovum absque vitello corpore luteo formatum.

19. Macropus.
20. Hypsiprimnus *Illig*.
21. Phalangista.
22. Petaurista.

Ordo 2. Ovum vitello instructum.

23. Phascolarctos.
24. Didelphis.

ECMETROA.

GENERA.

Ordo 1. Penis bifidus, aperturis novem.

25. Ornithorhynchus.

Ordo 2. Penis bifidus, aperturis quatuor.

26. Echidna.

Exostoa.

Genera.

Ordo 1. Nidus planus rudis ex ramulis virgisque sine involucro interiore laxe constructus.

27. Falco.

Ordo 2. Nidus concavus ramunculis graminibusque laxe constructus involucro interiore.

28. Corvus.

Ordo 3. Nidus virgulis tenuioribus arcte constructus involucro molli interiore.

29. Turdus.

GENERA.

Ordo 4. Nidus tenuior laxe constructus involucro interiore.

30. Sylvia.

Ordo 5. Nidus pendulus subsphæricus miranda solertia contextus.

31. Fringilla.

Ordo 6. Ova bina super terram deposita ligni fragmentis laxe cincta.

32. Columba.

Ordo 7. Ova numerosa nido hemisphærico super terram deposita.

33. Phasianus.

Ordo 8. Ova perpauca locis humidis deposita.

34. Vanillus.

GENERA.

Ordo 9. Ova deposita locis excelsis.

35. Ardea.

Ordo 10. Ova absque nido prope maris lacuumque litora deposita.

36. Larus.

Ordo 11. Ova nido deposita ad lacuum insalsorum margines.

37. Anas.

Ordo 12. Ovum solitarium rupibus maris depositum.

38. Uria.

ENAEROGENOA.

GENERA.

Ordo 1. Penis intrans simplex.

39. Lacerta.

Ordo 2. Penis intrans duplex.

40 Coluber.

Ordo 3. Penis nullus.

41. Rana.

Amphibigenoa.

Genera.

Ordo 1. Pedes antici tetradactyli, postici didactyli.

42. Proteus.

Ordo 2. Pedes antici tetradactyli, postici pentadactyli.

43. Axolotia.

Ordo 3. Pedes antici tridactyli, postici nulli.

44. Siren.

Enhydrogenoa.

Genera.

Ordo 1. Embryo ex ovo vel in oviducto vel in mare libero evolutus.

45. Squalus.

Ordo 2. Embryo ex ovo prope ortum fluviorum deposito evolutus.

46. Salmo.

Ordo 3. Embryo ex ovo in graminibus aquaticis deposito evolutus.

47. Silurus.

Ordo 4. Embryo ex ovo in plantis ad margines fluviorum deposito evolutus.

48. Esox.

GENERA.

Ordo 5. Embryo ex ovo vel in oviducto vel in mare deposito evolutus.

49. Clupea.

Ordo 6. Embryo ex ovo in pulvinis arenosis maris deposito evolutus.

50. Pleuronectes.

Ordo 7. Embryo ex ovo in mare profundo deposito evolutus.

51. Mullus.

Ordo 8. Embryo ex ovo in arenis maritimis deposito evolutus.

52. Gadus.

Metamorphogenoa.

Genera.

Ordo 1. Embryo ex ovis caudæ affixis.

53. Cancer.

Ordo 2. Embryo ex ovis pedibus anterioribus affixis.

54. Aranea.

Ordo 3. Embryo ex ovis sub epidermide cutis vel ventriculi depositis.

55. Œstrus.

Ordo 4. Embryones ex ovis plurium generationum unico mare impregnatis.

56. Aphis.

GENERA.

Ordo 5. Mater unica rempublicam producens.

57. Apis.

Ordo 6. Embryones ex ovis in aqua depositis.

58. Phryganea.

Monogenoa.

Genera.

Ordo 1. Ova racematim connexa.

59. Sepia.

Ordo 2. Ova in cameris membranaceis imo maris affixa.

60. Voluta.

Ordo 3. Ova in cameris membranaceis super cochleam parentis depositis.

61. Janthina.

Hermaphroditogenoa.

Genera.

Ordo 1. Individua duo mutuo sese impregnantia.

62. Helix.

Ordo 2. Individua quatuor aut plura in circulum connexa se invicem impregnantia.

63. Bulinus. *Adans.*

Autogenoa.

Genera.

Ordo 1. **Piscerina.**

64. Muræna.
65. Petromyzon.

Ordo 2. Animalia tubo calcario inclusa.

66. Teredo.

Ordo 3. Animalia testa bivalvi.

67. Ostrea.

Ordo 4. Asteroidea.

68 Asterias.

Cryptogenoa.

Genera.

Ordo 1. Animal membranaceum absque organis internis.

69. Cysticercus.

Ordo 2. Animal gelatinosum organis internis manifestis.

70. Medusa.

Ordo 3. Animalia sæpius aggregata, forma determinata, stirpe externa, cornea.

71. Sertularia.

GENERA.

Ordo 4. Animalia sæpius aggregata, forma determinata, stirpe interna, cornea vel lapidea.

72. Gorgonia.

73. Isis.

APPENDIX.

APPENDIX.

[This Appendix contains Notes in Addition to several of the preceding Lectures.]

Note to Lecture Fifth.

The narwal has been *hitherto* considered to have no incisor teeth; this is now found to be incorrect. When very young, the animal has two small incisors in the upper jaw, between the orifices through which the tusks are to pass out. This is here mentioned to show the analogy with the dugong. These teeth, as in the whale, form in the gum.

Mr. Brookes, teacher in Anatomy, showed me these incisor teeth in the recent animal.

Captain Frankland, in his overland journey to the Arctic Sea, observed that the rein-deer fed on the canomyce rangiferina, a lichen, acrid and disagreeable to the taste, and difficult of digestion. The Indians consider it improved in these respects, when it has been some time in the first bag of the deer's stomach. The Iceland moss, cetraria islandica, is never eaten by the natives, although met with in abundance.

The daily allowance of animal food issued to the Canadian hunters, is eight pounds of the prime buffalo beef, bone included. They commonly make soup. When they roast it, they cut it off the spit, so that it is never much done. They take no bread, salt, or vegetables. They are seldom met with fat, but the Canadians on the coast, who live on fish, and eat more salt, look better, bear more fatigue, and grow fat.

Note to Lecture Seventh.

The tortoise from the Saychelle Isles has the under shell externally concave, which makes it buoyant upon water by the air confined in this concavity. One of these animals, of great weight, lived in the Earl of Egremont's park, and was seen frequently to swim across the pond with the utmost ease; and when it came to land, the upper part of the concavity was found dry.

Captain King, who surveyed those parts of the coast of New Holland that had not been examined by Captain Flinders, told me that the turtles, which are in great abundance, swim at the rate of about three miles an hour. They are speared by the natives, while swimming, in the neck with great dexterity.

Respecting the unicorn of Job, ch. xxxix. v. 9. The word in the Septuagint *μονοκερως*. The Hebrew, ראם, *i. e.* Ram, which means any thing with an exalted horn, and therefore may mean rhinoceros as well as unicorn. It is from a verb of the same letters, which means, to exalt.

Note to Lecture Eighth.

Mr. Morecroft, in Chinese Tartary, which is elevated eleven thousand feet above the sea, ascending one of the gauts in a hail storm, in 1821, had several of his people struck blind by the reflection of the sun from the ice crystallized in falling. The intense heat and

light destroyed the sensibility of the retina in the course of half an hour. These effects were prevented by wearing black veils.

Note to Lecture Tenth.

Susan Philips, at the age of thirty-nine, after having fourteen children, when four months gone with the fifteenth, had a frog of a large size, thrown from a waggon-load of hay, that fell upon her left shoulder, and upon that foot. She had not then quickened; she never recovered the fright, but dreamt constantly distressing dreams respecting frogs and toads.

The child, who is now sixteen, is about three feet high. Has no arms below the elbows, the stumps of a conical form, terminating in a finger on which is a nail. The left foot has only four toes, and these are in a degree webbed.

A woman seven months gone with child had quickened, and was going on well; a favourite bird she had in her hand escaped and flew away. The flurry made her faint, and it was hours before she recovered herself. The child never afterwards moved. No child was born. The size of the body never diminished. A large abcess formed, which was opened at the naval in St. George's Hospital, and the bones of a seven months' child were gradually taken away, and she got perfectly well.

" My Dear Sir,

" In the course of above forty years' practice, I have met with many instances of women being much distressed in their minds, from an apprehension that some fright they had met with during their pregnancy, would occasion some defect or deformity in their expected offspring. But happily in no single instance, where such fears had been expressed previous to the delivery, has the dreaded effect been, to my knowledge, produced.

" The case you enquire about was certainly the most extraordinary that I have ever met with; and since the publication in the Philo-

sophical Transactions, of the effects produced on the succeeding progeny of Lord Morton's mare, after she had been once impregnated by a male quaggar, I have thought that this case, as appearing to have some analogy to it, might be worthy of being recorded.

"The lady of a member of Parliament, in one of her pregnancies, but at what period of the gestation I do not recollect, was extremely frightened by a beggar thrusting his stump into her carriage window. The fright made so strong an impression upon her, that during the remainder of her pregnancy, it constantly haunted her imagination with the dread that her child would suffer from it; and so firmly was this idea impressed upon her mind, that when the infant was born, neither the assurances of her attendants, nor of myself, that its hands were perfect, could at all pacify her, till she was convinced by the evidence of her own senses from the child's being taken to her.

"During this lady's succeeding pregnancy she met with no fright, and seemed to think no more about her former distress, for when the child was born she made no enquiries about its hands; but I immediately discovered that one of them was defective in the very way that she had so much dreaded in her former pregnancy, being entirely wanting.

"I leave you, Sir Everard, to judge whether the alarm this lady suffered might not have the effect of occasioning some change in the ovarium, which determined the form of the fœtus in the succeeding conception, in a way analogous to what took place with Lord Morton's mare, and with the sow that had been impregnated by a wild boar, or whether in this case the coincidence ought rather to be considered to be purely accidental.

"I am, with respect,

"Yours very truly,

"JOHN SIMS."

Wimpole Street,
June 30. 1823.

From the case stated in this letter and the others that have been noticed, I am disposed to draw the following conclusions.—

Violent affections of the mind appear not only capable in some rare instances of destroying the child in utero, or arresting the growth of some parts of its body, but even of influencing the ovarium in its actions while forming a corpus luteum, so that the ovum previous to impregnation shall have a bias given to it, making the embryo decidedly marked in consequence of it.

Note to Lecture Thirteenth.

The opinion advanced in this Lecture of the earth-worms mutually impregnating each other, does not appear supported by evidence. I therefore consider them as self-impregnating animals, for which purpose the testicles and ovaria are admirably situated respecting each other. The agitation that takes place during the copulation will make the testicles burst, and spread the semen upon the ova. The wriggling motion of the worms may force the ova into the numerous decipimenta in which they are met with; a distribution that could not take place while the animals remain in a state of rest. Their continuing to copulate from June to December, will, from this explanation, be readily understood.

Note to Lecture Fourteenth.

In Sprat's History of the Royal Society, page 199, he mentions an entry "of eggs proving fruitful after being frozen:" "an account of freezing by Mr. Marriot, was before the Society, 30th December, 1663," and entered in their minutes, wherein, after detailing some experiments on the freezing of eggs and apples, he says, "Whether eggs once frozen will produce chickens or no, I cannot say, but have been told by good housewives they do." This observation is disproved by what has been stated at the end of this Lecture, on the

freezing of eggs, and the fallacy of Marriot's remarks is confirmed by the following experiments made in June, 1823.

My former experiments having ascertained that when an egg is completely frozen and then allowed to thaw, the albumen is restored to its former state, but the molecule has become a limpid watery liquid, in which a number of globules of a gazeous vapour are let loose.

They, however, only proved the change having taken place in the molecule, but did not determine that it had, in the first instance, become hard; I therefore requested my friend, Mr. Hatchett, to repeat the experiment, which he did in my presence, with the assistance of Mr. Farrady, in the Elaboratory of the Royal Institution. We succeeded in every thing but the object of the experiment, which was to examine the molecule before it thawed; for being surrounded by ice, the parts thawed before we could separate them.

This experiment was therefore again made under the following circumstances: the shell covering the molecule was removed, and the egg put into a mould of lead with a cover of the same metal. Another egg had half the shell and half the albumen removed; a third had both shell and albumen taken away, leaving the yelk only to be frozen. These three eggs, enclosed in lead, were frozen, and in my presence examined by Mr. Bauer. The molecule was distinctly seen forming a white opaque hard substance, readily removed from the surface of the yelk in which a depression was left; a number of globules were seen in this opaque substance, which appeared to increase as it thawed, and nothing but water and these globules remained.

The yelk was quite hard, and a section of it shewed concentric circles from the circumference to the centre; to the taste it was exactly similar to napkin cheese. The albumen formed needle-like crystals, in direction from the yelk to the shell. In neither of these parts were any globules evolved.

Note to Lecture Fifteenth.

A friend of the author who lives in the country, in England, and is particular respecting his poultry, has a Chitigong cock from Sumatra, and some Lucknow hens from Bengal, which breed nothing but cock-birds without one single exception, although English hens trod by the same cock lay eggs that produce chickens that are female as well as male.

I ate one of the eggs of the Lucknow hens, which differed from other eggs in having a brown shell: the albumen was not white but had a bluish tint, more like that of the plover: it was weak in its texture, and in the mouth seemed almost to melt like common jelly; the yelk was less condensed.

Two emus in the year 1823, from New South Wales, belonging to the King, bred in Windsor Park. The male sat upon the eggs which were hatched in the exact period of nine weeks, they were 6 in number.

The egg of the emu is five inches long, three inches and seven-eighths broad. That of the ostrich six inches long, four inches and one-eighth broad.

This fact respecting the emu leads to the belief that in a country like Africa, where such heavy dews take place, the ostrich also sits on its eggs, especially during the night.

A friend of the author in Staffordshire kept two swans upon extensive waters which belonged to his estate. In the year 1809, the cob died. The female left these waters and took up her abode, at a farm two miles distant, with the geese. After remaining in this society till 1812, she made a nest, laid three eggs, and had sat upon them for about two weeks, when, unluckily, the farmer, who knew that there were no swans within the distance of twelve miles,

took up the eggs and kept them as curiosities. Upon being broken some time after, they were all found to have young birds in them.

As the goose sits four weeks, the swan five, there can be little doubt of the latter period being necessary for hatching the swan's eggs, which explains the circumstance of the farmer not feeling, by the weight, that the embryo in two weeks was formed.

END

London
Printed by A. & R. Spottiswoode
New-Street-Square.